NAVSEA TECHNICAL NOTE
NO. 070-PMS335-TN 0018

NAVSEA

C4I
MODULAR IMPLEMENTATION WORKING GROUP

Shipboard Modular Arrangement Reconfiguration Technology

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C4I MODULAR FOUNDATION STUDY

UNCLASSIFIED

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C4I Modular Foundation Study

W. A. Smithers

Approved PMS335

6/17/96

Date

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Documents from a historical and technical perspective along with continuing efforts, the various modular concepts (foundation system) and designs that were developed and analyzed as potential components of the "SMART Modular Arrangement Reconfiguration Technology (SMART)" concept. The concepts and designs to be discussed will demonstrate the feasibility and flexibility of the track system for rapid, efficient reconfiguration, or installation of new equipment either with minimum or no welding needed.

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Shipboard Modular Arrangement Reconfiguration Technology

SMART

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JUNE 1996
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C4I MODULAR FOUNDATION STUDY

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1.0 Introduction

1.1 Definition of C4I

The Command, Control, Communications, Computer, and Intelligence (C4I) Modularity Implementation Working Group (MIWG) was formed in September 1993 to identify and implement C4I Modularity concepts to be more responsive to the Fleet's emergent requirements for flexibility in C4I space utilization and reconfiguration. Future uncertainties in mission requirements and the need for multi-mission capabilities establish an increased value and need for this flexibility.

The MIWG supports the vision and goals of the Affordability Through Commonality (ATC) program (modularity, equipment standardization, and process simplification) to implement improved/more efficient assembly, installation, and test of major equipment and systems, with the ultimate goal of reducing the total cost of ownership of our ships.

The MIWG is chaired by NAVSEA PMS335T. Members include representatives from Puget Sound Naval Shipyard Detachment, Boston (PSNS Det Boston), Norfolk Naval Shipyard (NNSY), Space and Naval Warfare Systems Command (SPAWAR), as well as various technical codes and design codes from Naval Sea Systems Command. Selected field activities and laboratories were tasked to participate in and contribute to the MIWG to assess C4I Modularity concepts.

1.2 Scope

This report documents the C4I Modular Foundation System from a historical and technical perspective. Along with continuing efforts, the various modular concepts and designs were developed and analyzed as potential components of the "Shipboard Modular Arrangement Reconfiguration Technology (SMART)" concept. The SMART concepts and designs discussed will demonstrate the feasibility and flexibility of the foundation system for rapid, efficient reconfiguration or installation of new equipment. The foundation system design goals are to minimize welding, reduce associated cosmetic repairs, reduce the amount of usual installation support, and minimize space disruptions both internal and external to the C4I space.

The C4I Modular Foundation System modularity concepts and designs presented in this report are all within the realm of engineering feasibility. The adaptations of these concepts into new or overhaul ship designs is desirable.

2.0 C4I Modular Foundation System

2.1 Modular Foundation System Objective

The objective is to evaluate the complexity of the assortment of equipment foundations, and determine a modular foundation (equipment foundation interface) system compatible with the track system. To make this determination, a survey must be conducted to validate the types of foundations that are currently in use, thus requiring a compilation of different types of foundations from various foundation designers. Conceptually, this will require an examination of a representative sample of Ship Installation Drawings (SIDs) to identify the many types of foundations used. NNSY's contribution to this effort has already been completed and is included as Appendix (A). A cross-functional approach for data gathering will use the existing inputs from NNSY, and future inputs from SPAWAR, NISE EAST, and at least two Planning Yards to determine the extent of unique foundations. The information will be extrapolated to make recommendations for foundation development in conjunction with the foundation track system for the C4I SMART Space.

The goal is to evaluate and reduce the existing use of foundations presently used aboard Navy ships. Present applications tailor foundations for each piece of equipment installed. Each installing activity typically designs their unique foundation, welds it in place, grinds and paints the welds and foundations, and then discards the foundation when the equipment is removed/ replaced.

During 1993, NNSY alone produced more than 1,100 drawings for NISE EAST AIT installations. This number of drawings does not include the drawing efforts NNSY accomplished for their own in-house installations. Over the last three years, more than 6,000 AIT installations were conducted. Each installation normally includes several foundations. At this point in time, no one really knows the number of types of foundations; the cost to design, manufacture, and install these foundations; or even the extent of how families of common foundations are utilized throughout the Navy.

A database for foundations will be established, showing as a minimum: (1) name, (2) drawing number, (3) total number in use, (4) man-hours to design foundation, (5) manufacturing cost, (6) applicability to types of equipment, and (7) applicability to classes of ships.

Note: Actual costs will be used when available for (5), otherwise, the estimated costs from the Planning Yard - Planning and Estimating (P&E) will be substituted.

See Appendix A for a report containing (1) a baseline summary of the database, (2) an explanation of the search parameters and findings, and (3) the representative cost for small, medium, and large foundations. Also included in the report will be a projected cost analysis on the average future cost per installation by using existing foundation techniques. The data was obtained from detailed SID reviews at PSNS Det Boston, NNSY, SPAWAR, and NISE EAST as mentioned above.

At the March 1995 MIWG meeting, the committee outlined the SMART Foundation goals. These goals were based on the recommended foundation track system as defined in the October 1995 technical note C4I Modular Foundation Track Study (070-PMS335-TN 0014), Section 2.8. The technical note recommends the use of track spacing of 12" on center (o.c.). Utilizing the light, medium, and heavy duty fittings as a mounting device for attaching the equipment foundations to the track, the goals are as follows:

1. Provide for vertical height adjustment.

2. Provide for rotated or angular equipment installation.
3. Provide for transverse and longitudinal movement.
4. Keep it simple (minimal parts).
5. Design the foundation to be flexible (can be moved to any location including orthogonal).
6. Design one foundation for each unique equipment, to be used Navy wide.
7. Minimize the weight (light enough for a single person to carry and mount).
8. Make the hardware accessible for mounting foundation and unrestricted track system access.
9. Use commercial-off-the-shelf (COTS) parts as much as possible.

As the foundation system evolved, not all of the goals were attainable, as will be noted throughout this document. One example of this is the "universal foundation" design, which met the goal of one foundation to fit all. However, this design resulted in an over design of the foundation system for light weight racks. Also, this system is the heaviest of the proposed designs (see Section 2.2).

A number of foundation proposals were presented by the MIWG for consideration. Some of the designs were an integration of a foundation false deck platform and a foundation base. Most equipment mounts directly to a fixed conventional foundation base. The SMART Space foundation must interface with the track system at any location. The foundation system must allow placement of equipment within one to two inches of any conventional mounting system layout to be considered a viable candidate.

2.2 Universal Foundation and False Floor System

On 21 February 1995, NNSY presented a prototype of a modular foundation assembly to the MIWG. This was followed up in March of 1995, when the prototype foundation system was redefined and presented to the MIWG as a proposal for a universal foundation system. The prototype foundation system will be discussed first.

The modular foundation (prototype) top surface was designed as a mounting platform that would include a false floor system and yet would be simple enough to be considered a "shelf item". Appendix B shows the one foot by two foot ganged foundation study providing a mounting surface made up of multiple foundation assemblies. One objection was that the foundation mounting had an eight inch by twelve inch footprint, which would not be compatible with the twelve inch by twelve inch on-center (o.c.) track system which was designed for 90 degree rotation of these assemblies. Also, the two foot wide sub-foundation surface would require a two (2) section wide assembly (48 inches) for a typical 29 inch wide command console.

In March 1995, NNSY redefined the prototype foundation and presented their conceptual design for a universal foundation and false floor plates, designed to be installed on the SMART Foundation Track System (refer to Figures 1 through 8). Both the equipment mounting plate and false floor plate measure 12" x 24" and 24" x 24" with the attachment base measuring 12" x 15". NNSY's objective was to design a mounting platform that would be inclusive of both a foundation and false floor system. With this design, as many foundation plates as necessary may be installed to support the foundation with the remainder of the deck covered by false floor plates (see Figure 2). Technical note "C4I Modular False Deck Study" (070-PMS335-TN 0015) provides a detailed description of the universal foundation. Therefore, only a brief description is provided of the universal foundation.

The foundation plates can be ganged together to form a hard platform. The foundation's leg is made of standard angular stock for the false deck foundation plates for simplicity, and the top and bottom plates of the platform are chocked, forming a true deck foundation for structural strength. The design was based upon the standard foundation track system loading for a rack weight of 1,690 lbs. This configuration provides a surface mounting area for direct hard mounting of equipment and would allow the equipment to be positioned at any location parallel or angular to the foundation panel envelope.

There were a number of drawbacks with the prototype system. Shimming for camber and shear to establish a level deck plane is required as the universal foundation systems (true and false floor) are not adjustable unless shims are used. The shims must be used in conjunction with the track fittings. The universal foundation for a command console would require four 12" x 24" wide foundation plates (8.0 sq. ft. platform), and would weigh 240 lbs. (steel) or 108 lbs. (aluminum). These factors, combined with the difficult access to the foundation plates for reconfiguration, resulted in the system being eliminated for further consideration.

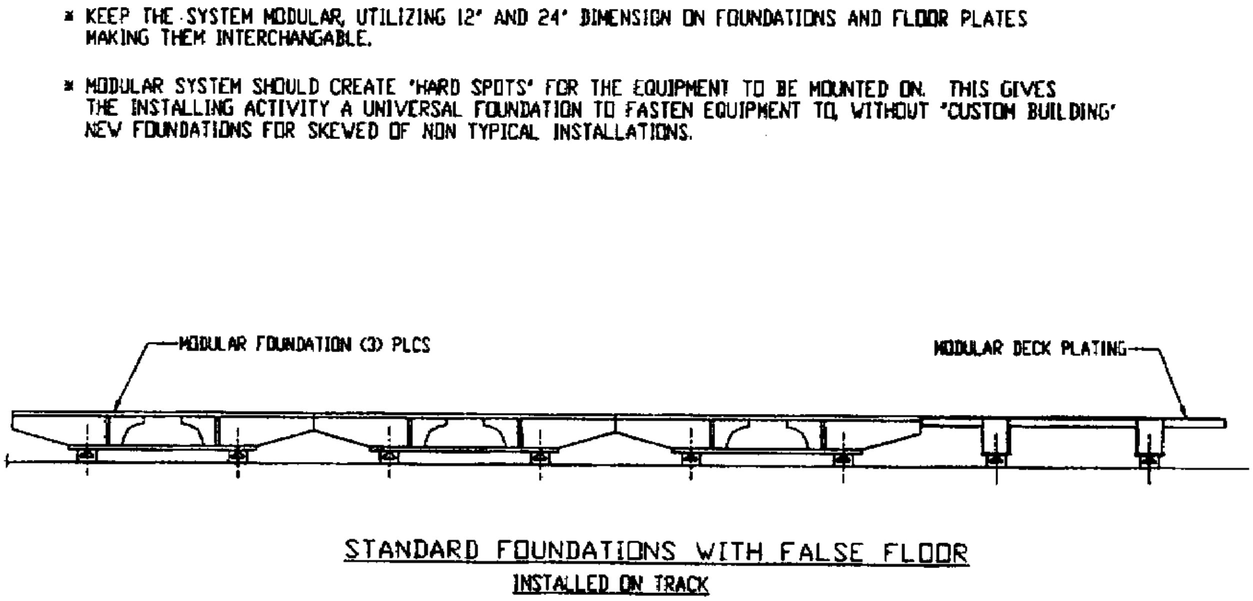
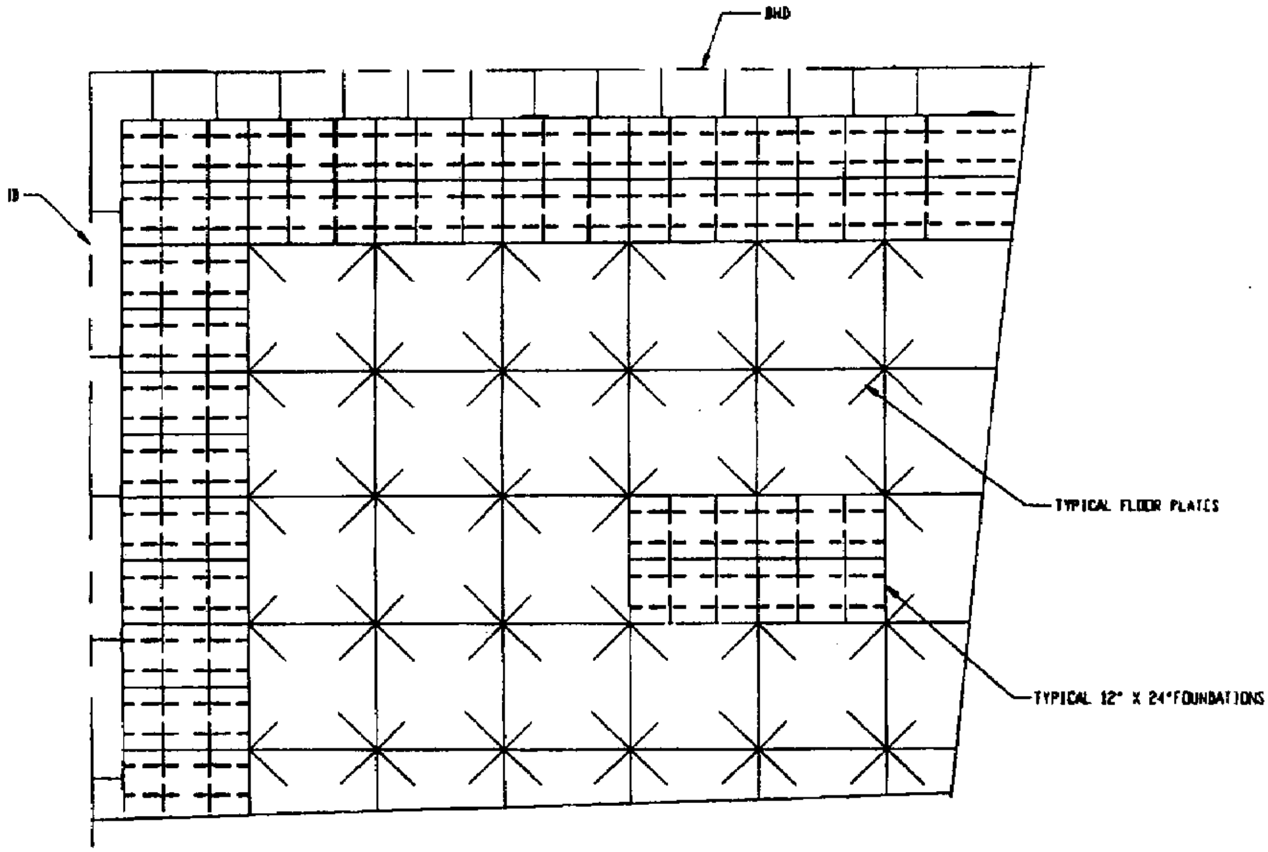


Figure 1: Universal Foundation with False Floor.



* EXAMPLE OF FOUNDATION AND FLOOR INTERFACE

Figure 2: Universal Foundation and False Floor Plan.

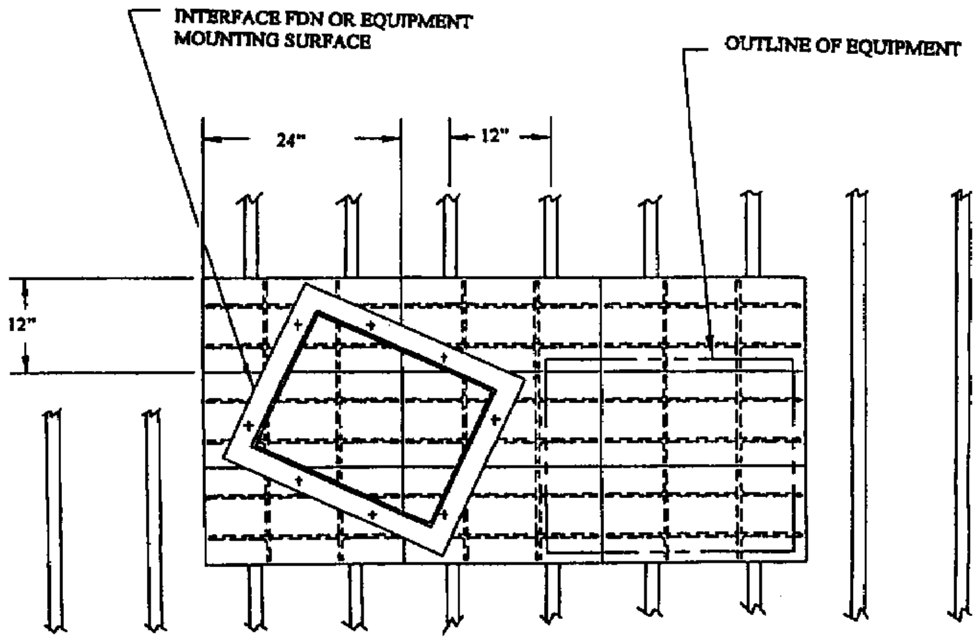


Figure 3: Universal Foundation with Equipment Foundation Plan.

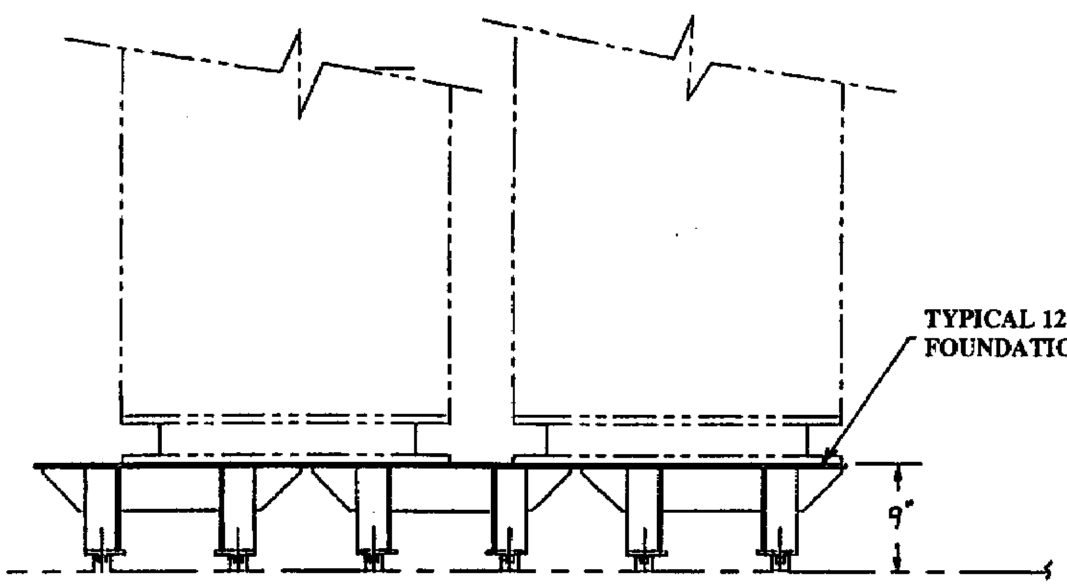


Figure 4: Foundation for 9" False Deck.

2.2.1 Foundation System (With False Deck)

At the November 1994 MIWG meeting, PSNS Det Boston presented a false deck system with a separate hard deck foundation (see Figures 5, 6, and 7). The PSNS Det Boston foundation approach was similar to the universal foundation. However, there are two significant differences between the two foundation systems including: (1) the PSNS Det Boston is a stand-alone foundation with the foundation designed to fit a specific location for a given equipment installation (this system provided a much simpler false deck approach than the universal foundation), and (2) the concept isolated the foundation from the false deck area resulting in a lighter weight system.

Figure 5 shows the PSNS Det Boston conceptual designs for installation of false deck panels, supports, and foundations compatible with the C4I track system, with consideration given for a variety of interfaces for skewed or offset foundations (see Figures 6 and 7). SMART False Deck Systems are addressed in Technical Note "C4I Modular False Deck Study (070-PMS335-TN 0015)". As with the universal foundation, the deck system (foundation) did not meet the design goals. The system is equipment and location specific, and did not provide the flexibility of reconfiguration utilizing the same foundation structure.

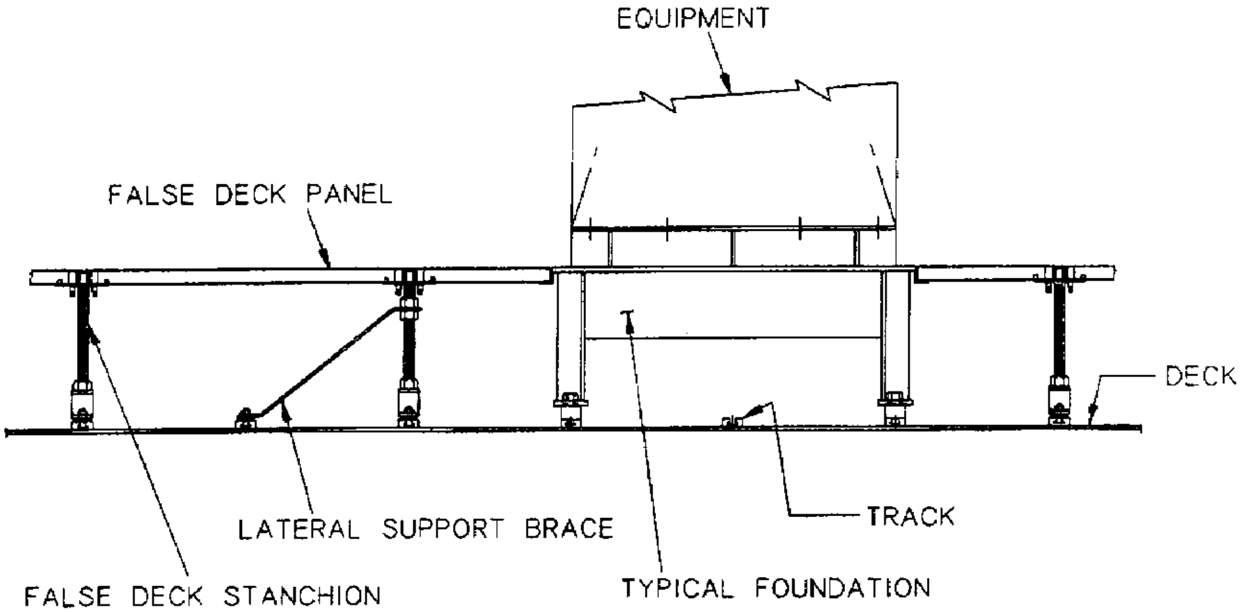


Figure 5: False Deck System Shown with Foundation.

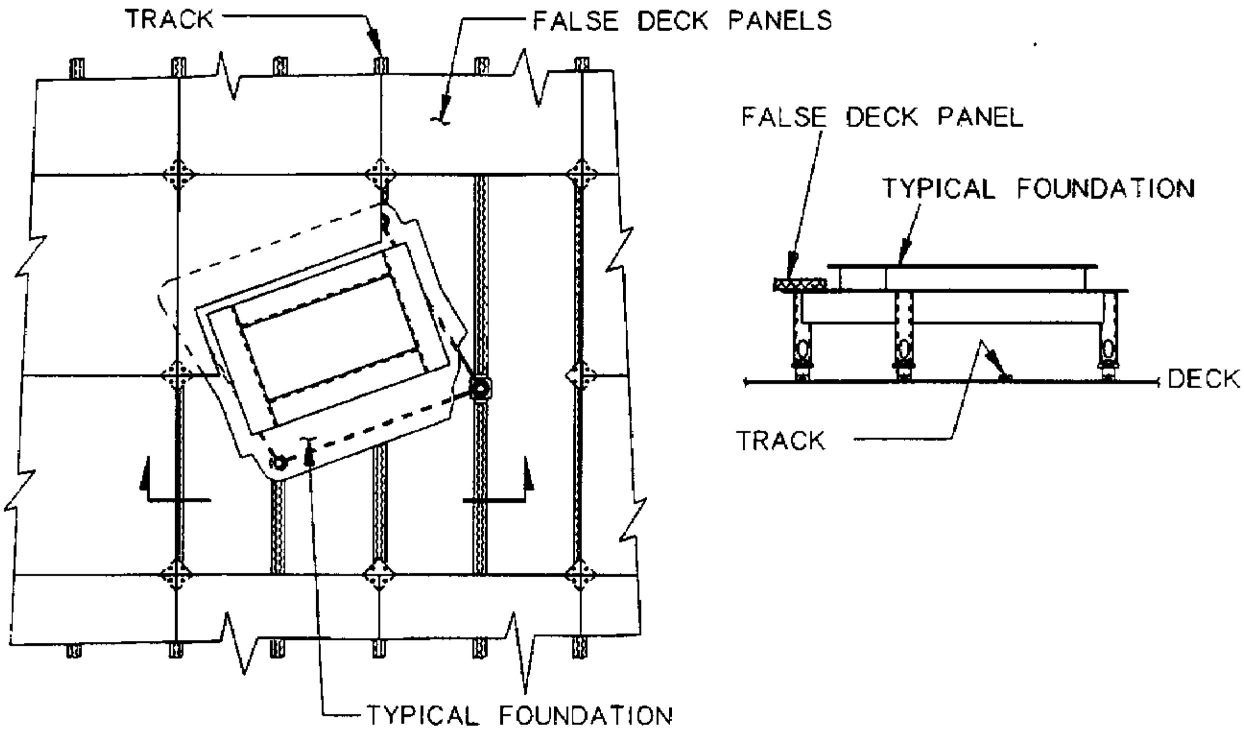


Figure 6: Track and False Deck System with Foundation Skewed.

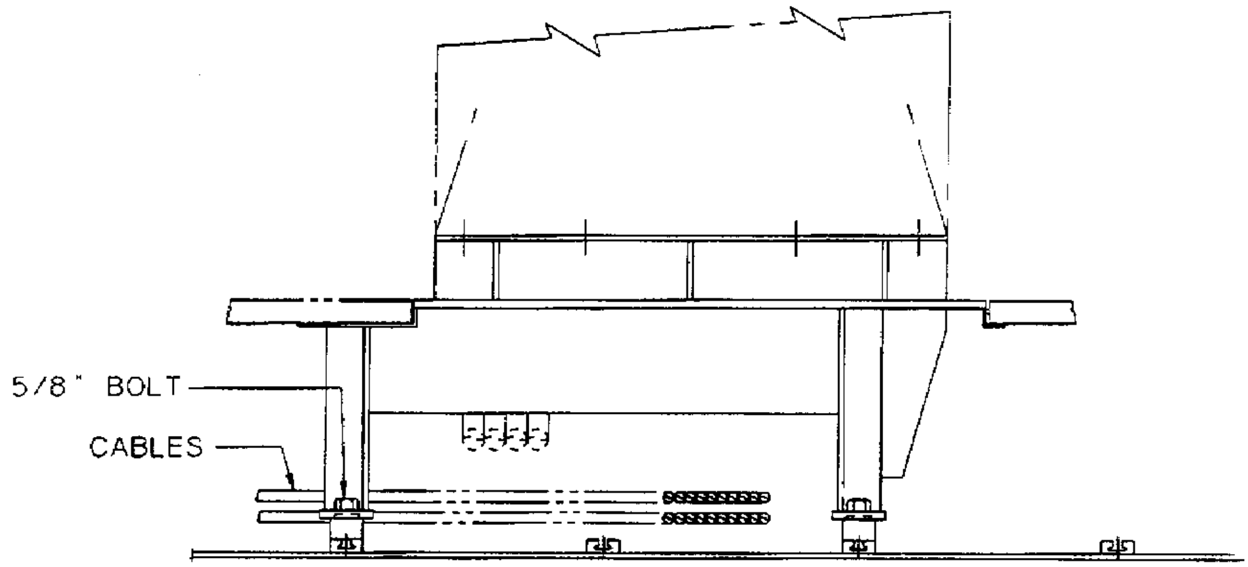


Figure 7: False Deck System with Foundation Offset From Track.

2.3 Adjustable Foundation Support

At the 21 February 1995 splinter MIWG, a field support activity proposed a tubular (pipe) shape, threaded for three to five inch vertical travel, providing a wide range of vertical height adjustment for both camber and shear, and nine inch or twelve inch false deck heights. The concept included an off-center mounting foot for attaching to the track fittings, providing the ability to offset the foundation. PSNS Det Boston objected to the off-center mounting foot. Their concern was that a moment arm effect by the foundation could occur under shock, placing excessive stress on the fittings. This led to a suggestion that placing a bolt through the column directly into the C4I modular fitting and boring the leg base to sit directly onto the fitting's shear boss would alleviate the off-center foot (see Figure 8). The redesigned adjustable foundation configuration would provide for camber, shear, and false floor height variances, and the placement of an offset plate on top of the adjustable column would allow for movement of the equipment. The design considers the variables of the current track system profile heights as defined in drawings 113-6904880 and 113-6904881. It was pointed out that there is a height difference of 0.729 inches between the track profiles and fittings (see Table 1 and Figure 9). When the track profile height variables are combined with the deck camber and shear, a height delta of three inches could be possible in some hulls. However, one inch shear was chosen for this example for a combined reference height range of over 1.9 inches. The foundation system design is a stand-alone adjustable leg that can be mounted at any position along the track, used with any combination of track fitting assemblies, adjusted to any height, and locked into position by a locking nut. The top of the column has a welded high strength plate for mounting a sub-foundation or equipment foundation. The adjustable leg and plate is designed to allow the equipment foundation to move perpendicular to the track at any dimension (0 to 6 inches) without relocating the leg. This design will also allow for any angular position desired, however, it may require additional leg supports (see Figures 10 and 11). The additional leg supports for angular positioning are not a disadvantage as the supports are small, light weight, and easily stored. The utilization of the leg supports without generating a new part (or new design) was a good trade-off versus a new foundation.

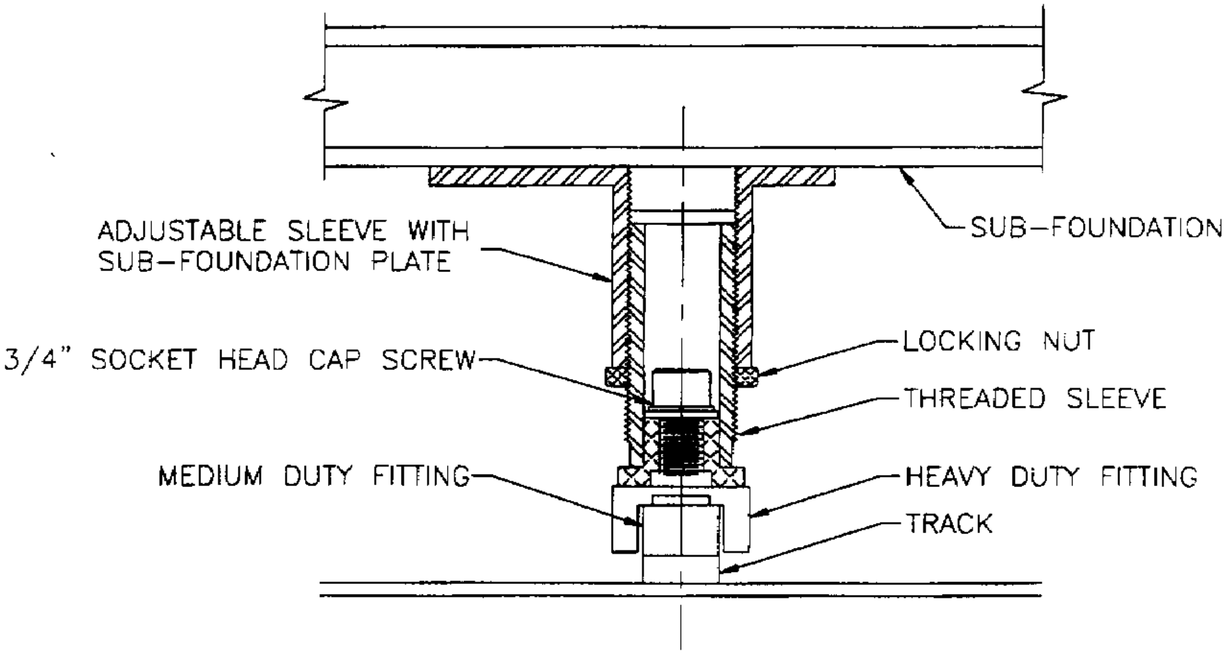


Figure 8: Adjustable Foundation Support Cross Section.

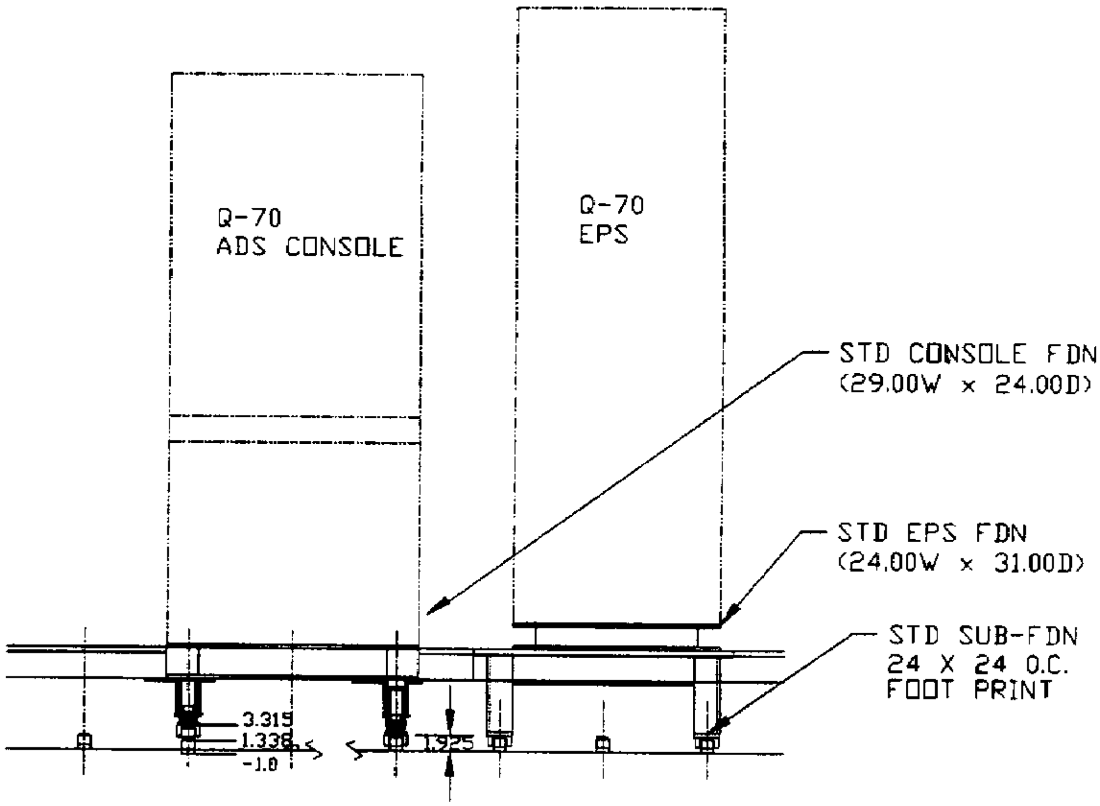


Figure 9: Height Adjustment for Foundation Track and Fittings.

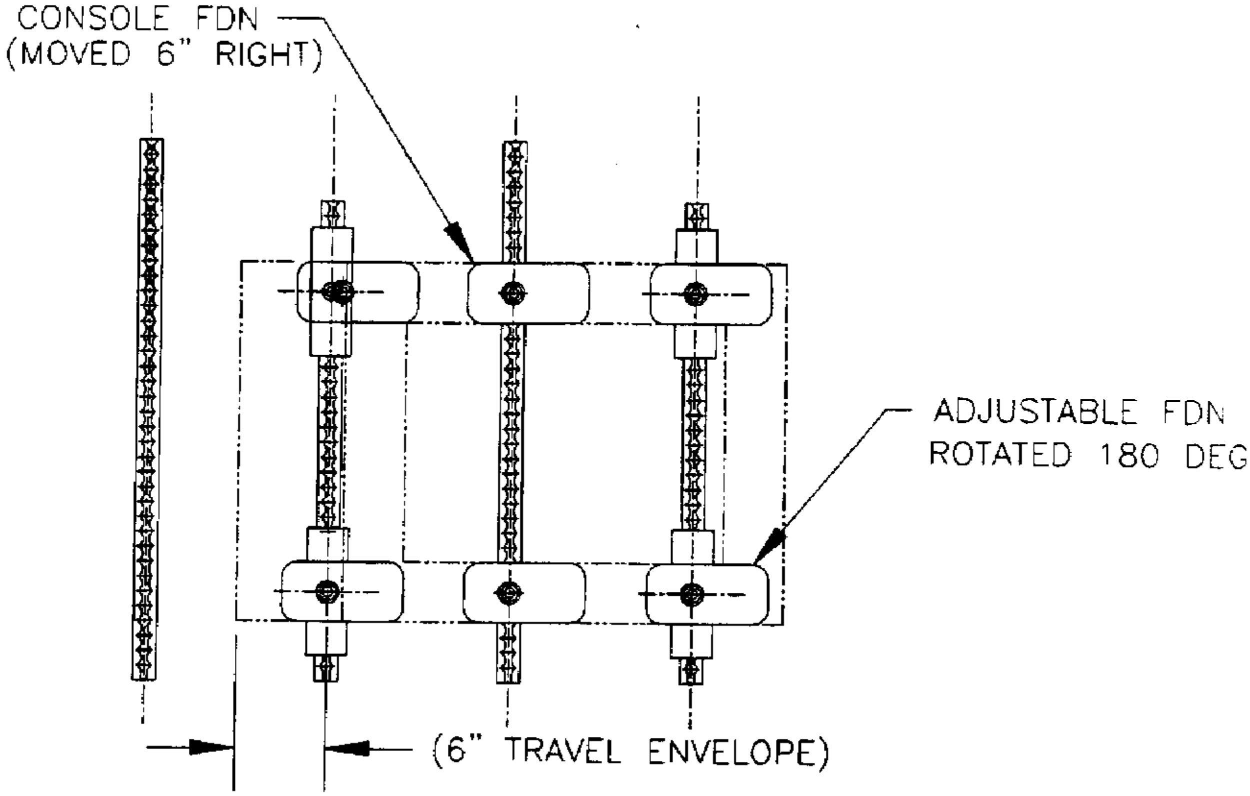


Figure 10: Equipment Located Normal To Foundation Track.

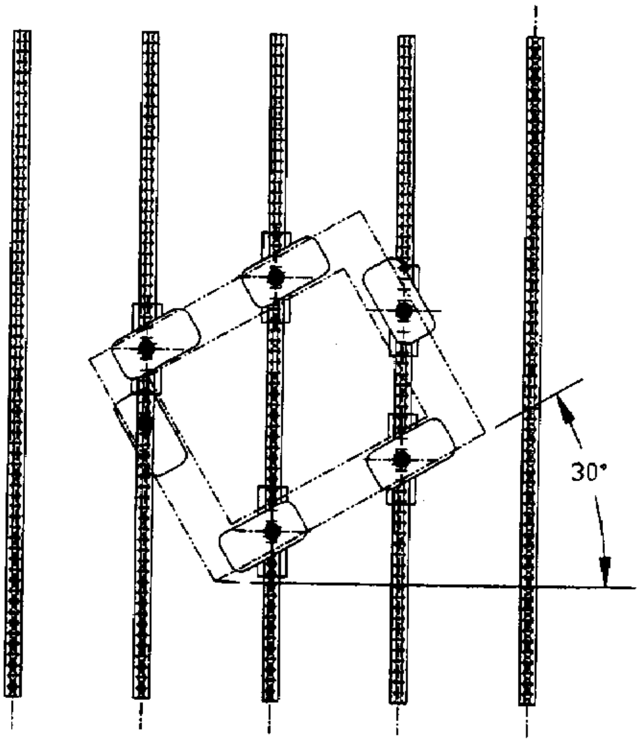


Figure 11: Equipment Located 30 Degrees To Foundation Track.

Item	Value
True Deck (Est. Avg. Shear)	Shear Range 1.00 (Est.)
Medium Fitting Minimum Height	1.550-.250 Commercial Aircraft Track and Fitting 0-.187 Negative unfairness 1.550-.212 MMC = 1.338 Min Height Med Fitting
Heavy Duty Fitting Maximum Height	2.279+.036 AL Track and Fittings +1.00 Shear 2.279+1.036 MMC = 3.315 Max Height HD Fitting
Height Difference	HD Range 3.315 Max MD Range 1.338 Min ~2.00 Adjustable Track Range

Table 1: C4I Smart Track System Profiles.

2.4 Adjustable True Deck Foundation

An adjustable foundation design was proposed for a true deck installation similar in design and concept to the Adjustable Foundation Support. The design incorporates a threaded leveling sleeve into the foundation (see Figure 12). The adjustment would allow for camber and shear for leveling. The track profile height delta is not affected as it is with a false deck, since the deck panel height above the true deck is relative to the track profile.

2.5 Sub-Foundation System

A sub-foundation that would fit between the foundation track system and equipment was proposed. The system would be very similar to a conventional foundation, however, the base plate or bottom of the foundation would not be welded to the true deck's support structure, but attached to the track. The foundation would bolt directly to the foundation track system. The foundation top plate was designed with mounting holes to accept the equipment. On the bottom plate, universal mounting holes are placed every 1.5 inches in one direction and three inches in the normal direction. PSNS Det Boston stated that pre-drilling is costly and recommended a "drill as required" condition relative to the equipment's location (see Figure 13). When the foundation is moved, new mounting holes are drilled.

2.6 Bi-Directional Foundation

An interesting concept for a universal foundation design was presented by a field activity and NAWCAD (St. Inigoes). The foundation itself is mounted to a series of sliding arms made from track that allow unlimited transverse and angular movement with a top plate for mounting a sub-foundation. Drawings are not available for this design, but a small scale working wood model was demonstrated. While the sliding foundation concept would provide the most flexibility for foundation movement, the design would not allow height adjustment and required several moving parts. This system is a buildup of track and fittings, utilizing a modified variation of the current fittings attached to the current track system. A track piece is turned upside down and attached to another modified track fitting with a top plate attached to an upper track piece. This arrangement would allow for track movement in increments of one inch in two (2) directions. In addition to linear movement, proportional incremental angular positions are made possible by positioning the fittings and assembly into a parallelogram and securing it to the track. This configuration provides a platform for attaching a separate sub-foundation to mount the equipment. Structural calculations are not available. Assembly height was dependent on the medium and heavy duty fitting, sub-foundation height, and shims. The one major drawback with this assembly is the multiple parts. The standard track fitting could be adapted with modifications; however, the sliding arms overlapped each other, restricting access to the tie-down or fitting hardware. The apparatus would require new and larger track fittings where the assembly cross arms lock together. Consequently, though interesting as a concept, the sliding foundation was not considered to be a viable candidate for a C4I foundation design, due to the multiple parts and the inability to access the fittings that are sandwiched between the crossing track members.

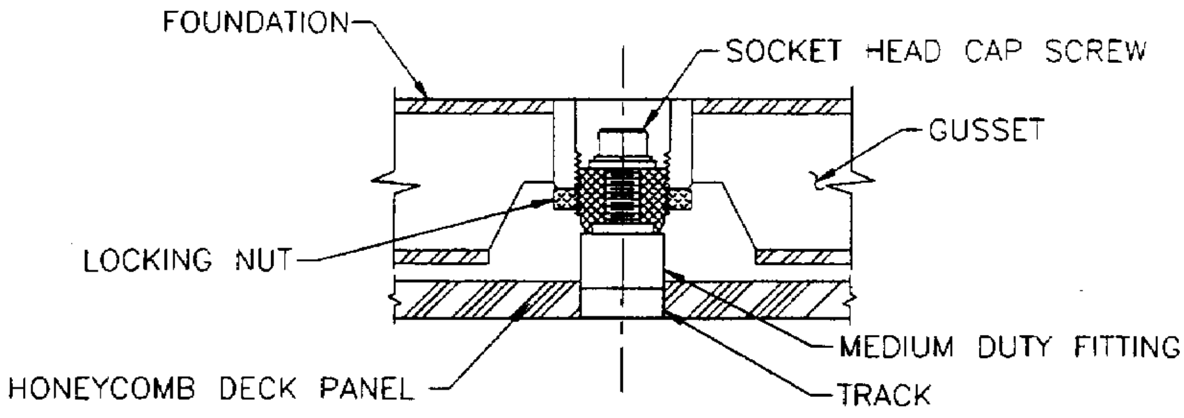


Figure 12: Adjustable True Deck Foundation.

2.7 Modular Foundation Adapter

The initial adapter fitting concept was based on an attempt by the MIWG to reduce the overall height of the track, fittings, and foundation while attempting to meet the foundation goals of providing angular placement of the equipment within a SMART Space. During meetings of the MIWG, there was discussion concerning the angular position required for placement of equipment at any angle between 0 and 90 degrees. The working group decided to target the specific angles of 15, 30, and 45 degrees. However, the adapter fitting design met all of the angular requirements, allowing the fitting to mount the equipment at any angle. A preliminary design was presented, at the April 1995 MIWG meeting, as two separate fittings (see Figure 14) .

Most foundation designs met the partial goals of the MIWG, but the modular foundation adapter design came the closest to these goals, meeting goals 2 through 9 (see Section 2.1). When the MIWG endorsed the "false deck modular frame system" to alleviate the labor intensive deck fairing, goal 1, "vertical height adjustment", was eliminated.

The modular foundation adapter provides a fully modular mounting assembly that includes a low-profile foundation designed for mounting equipment at any position angular or normal to the track (see Figures 15 through 17). PSNS Det Boston stated that the initial design of two fitting adapters (see Figures 18 and 19) can be modified into one adapter fitting. A shim plate can be utilized for a heavy duty application to raise the adapter above the heavy duty attachment bolts eliminating the need for two separate adapters. A bushing can be added to accommodate the 5/8" bolt for attaching to the medium duty adapter versus the 3/4" bolt used with the heavy duty adapter (see Figure 19). This change will reduce production costs and will require stocking only one adapter . The adapter assembly will provide the ability to completely arrange or rearrange equipment within a SMART Space without welding or structural modifications, and without redrilling the sub-foundation, meeting all of the foundation goals.

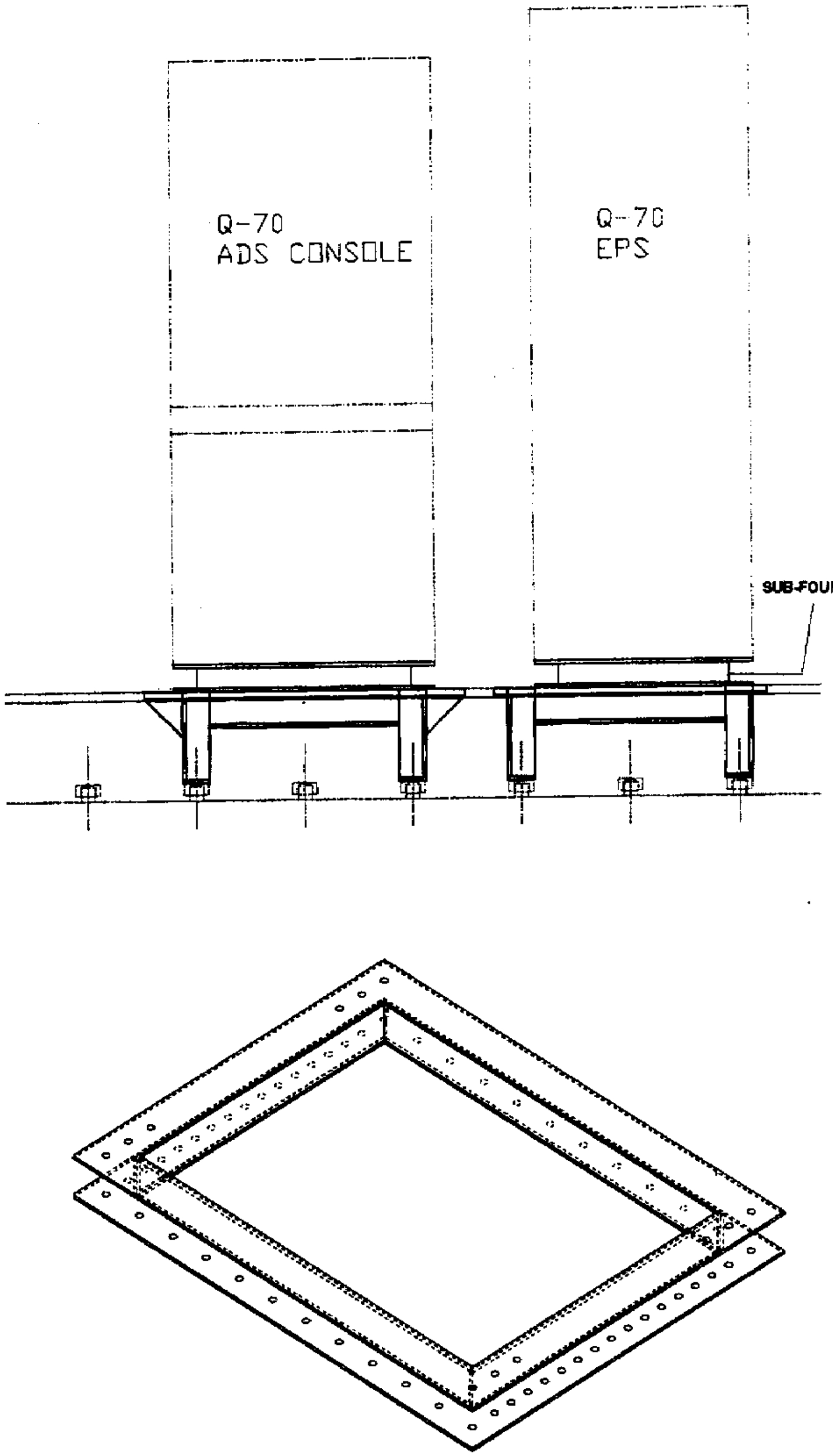


Figure 13: Sub-Foundation.

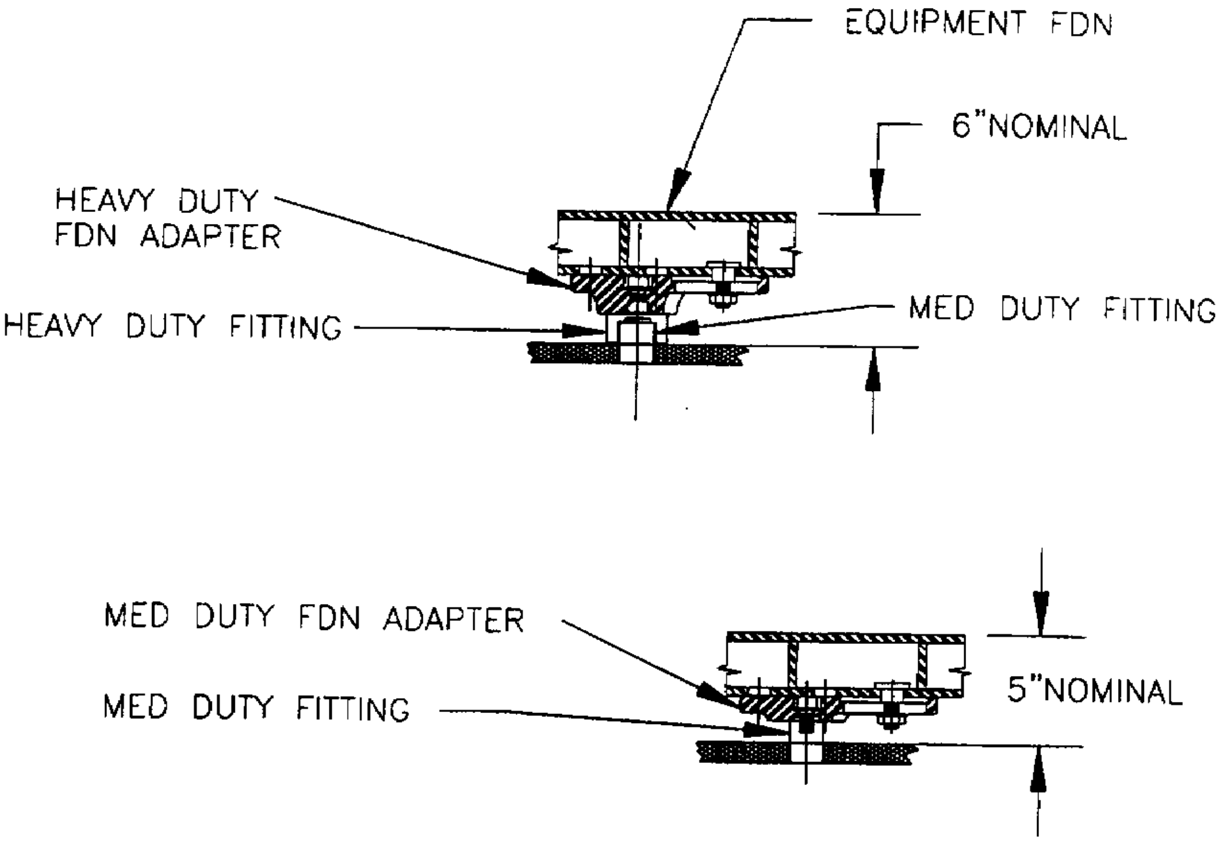


Figure 14: Typical Foundation and Fittings.

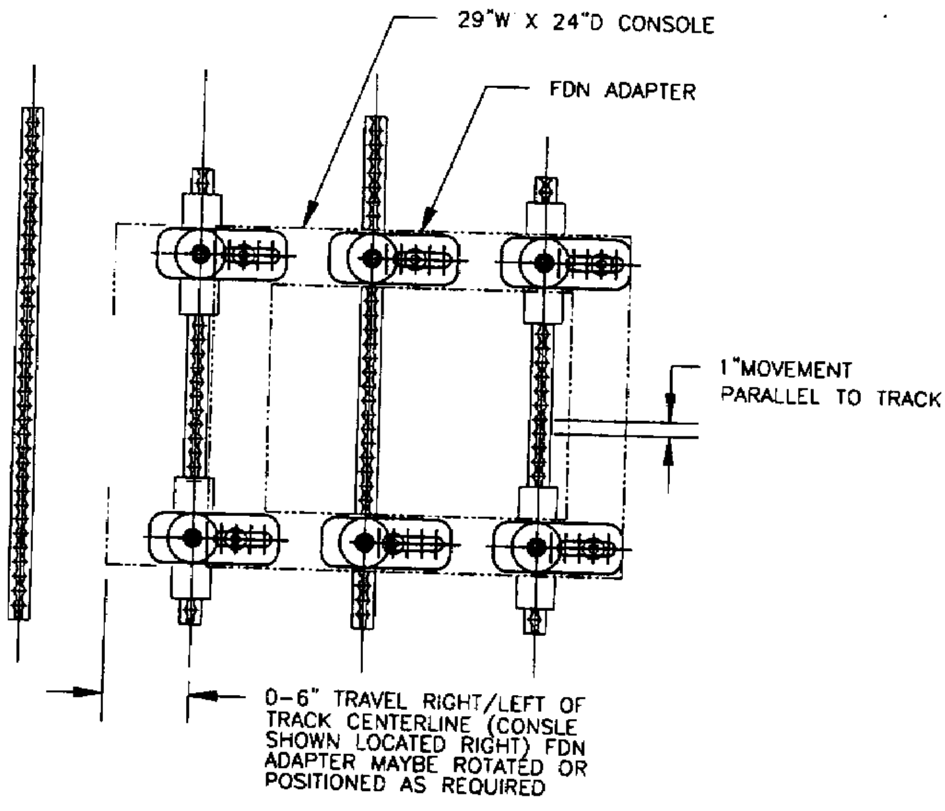


Figure 15: Typical FDN Movement Normal To Track.

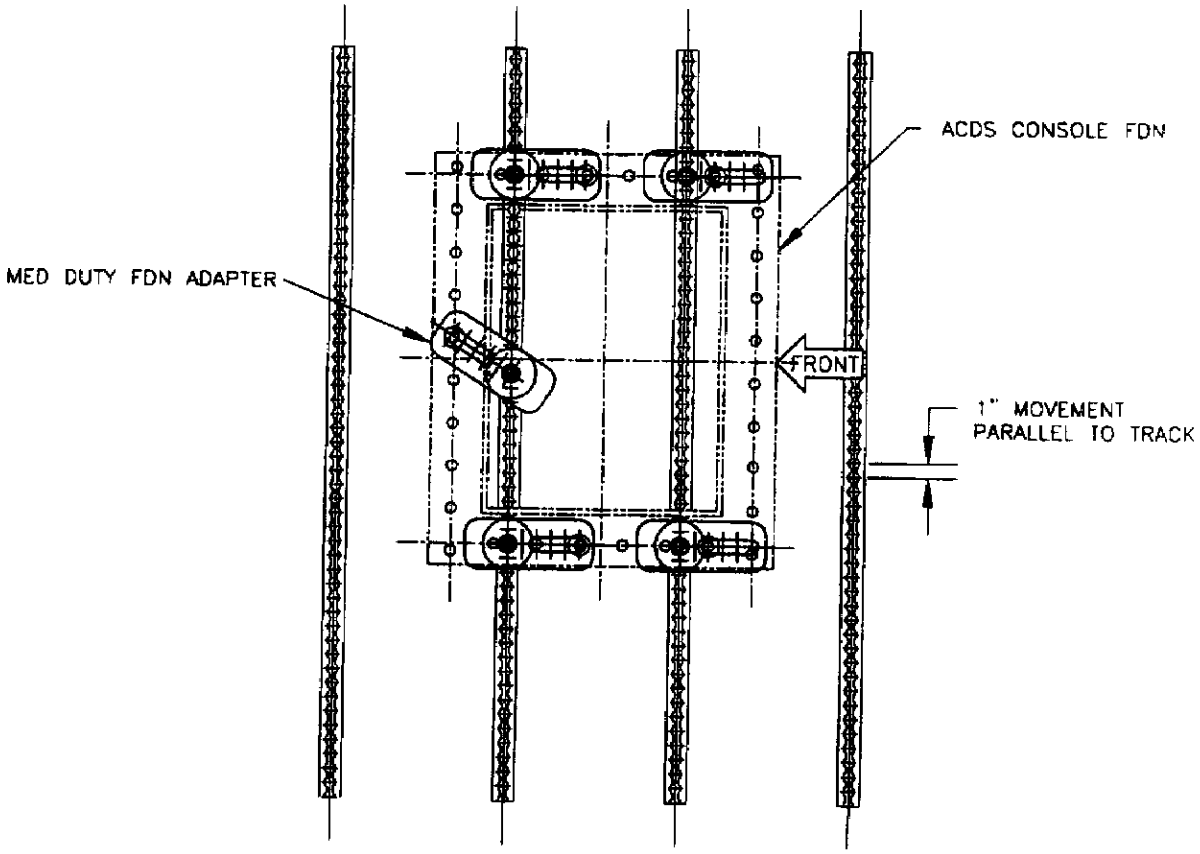


Figure 16: Typical Equipment Located Normal To Track.

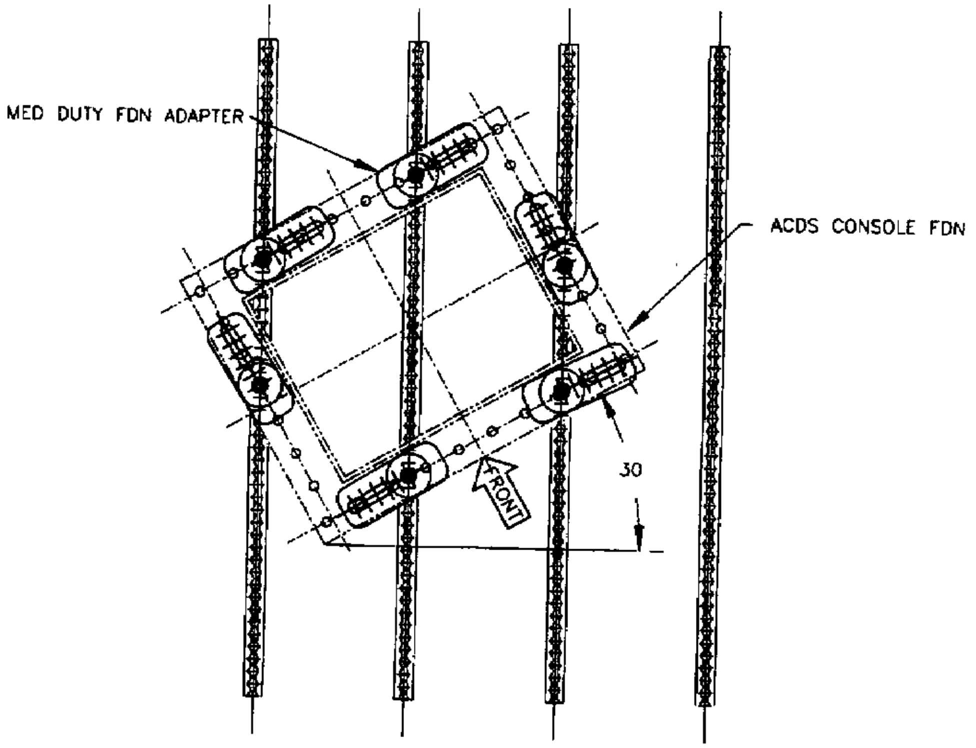


Figure 17: Typical Equipment Located At 30 Degrees To Track.

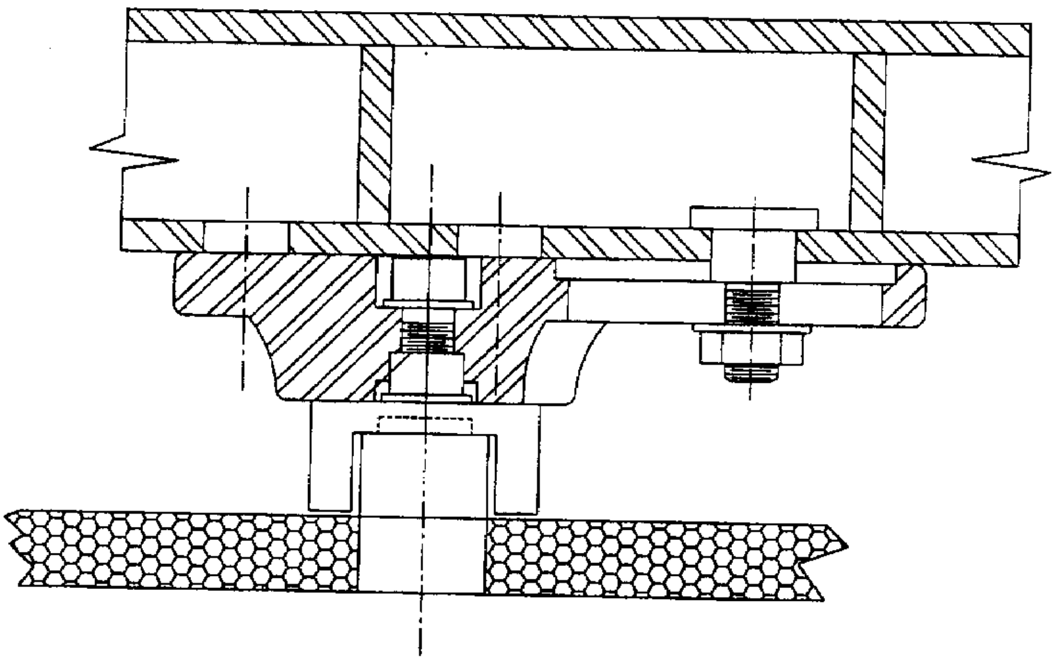


Figure 18: Heavy Duty Foundation Adapter.

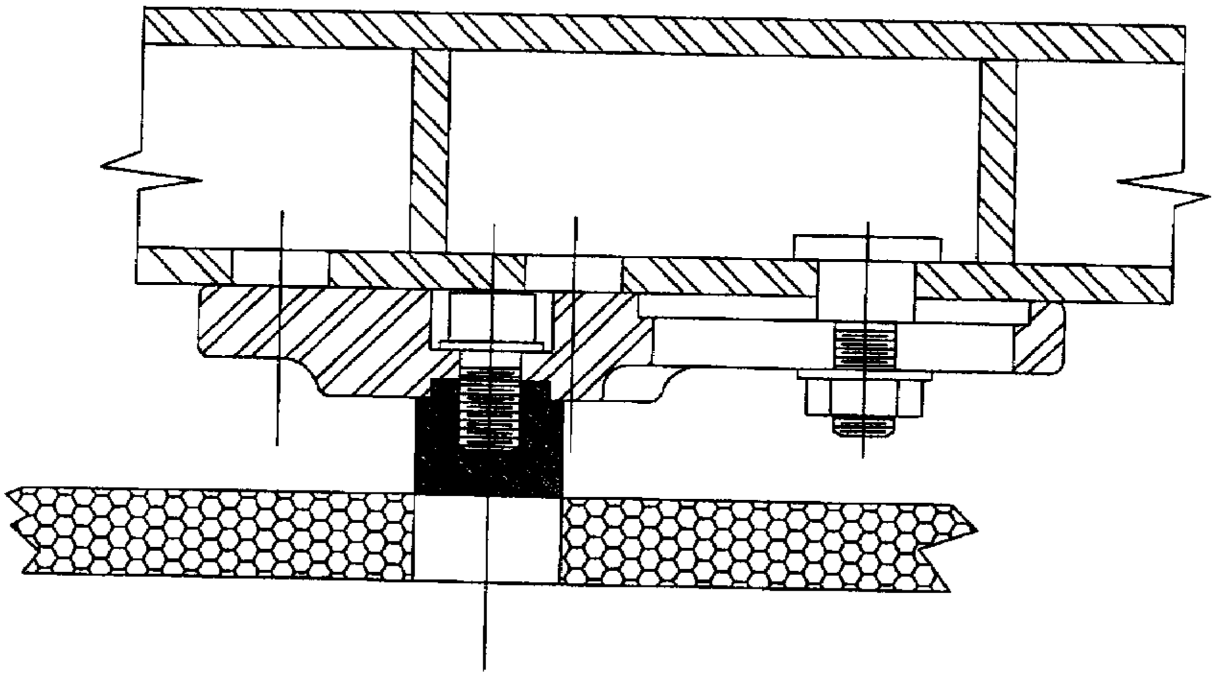


Figure 19: Medium Duty Foundation Adapter.

The final stage in proving the integrity of this design concept was to perform a finite element study to meet grade A shock requirements. NNSY performed the finite element study. The greatest stress observed during the study was determined to be the vertical shock load (see Appendix C). As a result of the study, NNSY recommended HY-80 strength steel and forging the fitting for maximum strength. The NNSY finite element study confirmed that the original adapter fitting design for a medium and heavy duty fitting could be redesigned for a heavy duty application and a reducer bushing could be added for use with the medium duty fitting (see Figure 20). NNSY continues to refine the adapter fitting for foundation mounting, and released a preliminary drawing "Modular Track Adapter Fitting" (113-7037309 Rev), see Appendix D.

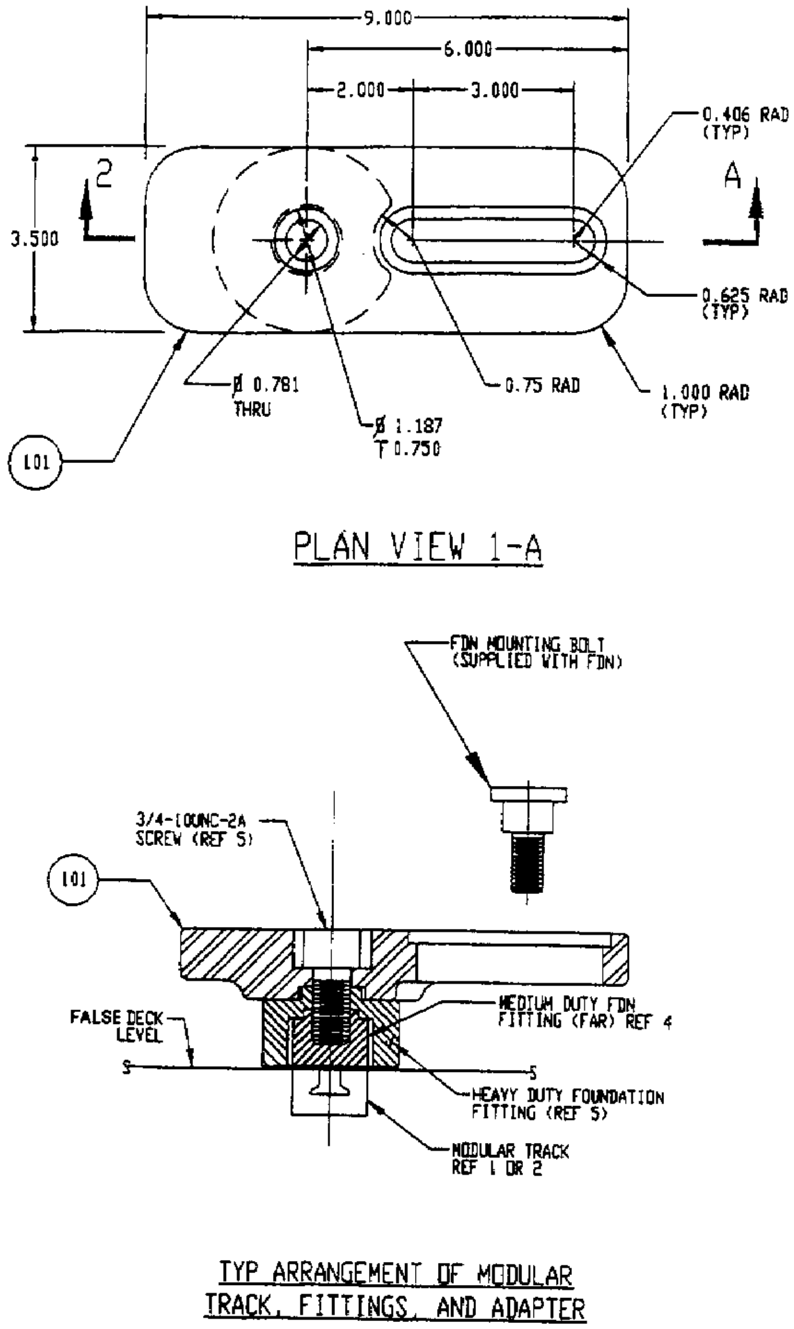


Figure 20: Modular Track Adapter Fitting.

2.8 Sub-Foundation (Equipment/Track Interface)

There have been numerous discussions within the MIWG concerning a universal sub-foundation (one sub-foundation that fits all). The MIWG has made every effort to review and evaluate all designs. The working group's evaluation of the current workable designs has resulted in the committee's agreement that a sub-foundation is required to attach the equipment to the track or fittings, and the equipment interface foundation must be unique for each equipment rack or console. The major reasons for a separate interface sub-foundation is that each rack, cabinet, or console footprint is unique to that equipment. The equipment manufacturers designs their own equipment to meet the requirements for grade A shock, vibration, access to the mounting holes, and size of the hardware unique to their cabinets. These unique requirements, when combined with the equipment weight range of 150 to 1,400 lbs., results in no two cabinets having the same dimensional footprint and weight. Therefore, to design a foundation structurally sound to withstand a specified vertical force, chocking of the foundation at the critical points of stress may not be compatible to the equipment mounting holes resulting in an over design for some racks, or an under design for racks twice as heavy.

The conclusion of the working group is that a standard interface foundation design and a type drawing should be developed for each piece of equipment applicable to SMART Spaces. The top plate or flange of each interface foundation will be compatible with equipment mounting and the bottom plate or flange will be drilled with holes that are spaced for track mounting at one inch apart (i.e., 16" not 16-1/4" or 16-3/4") around the foundation's centerline in both directions (see Figure 21). The bottom mounting holes shall be 1.25 inches in diameter in accordance with the slot radius of the adapter fitting and foundation mounting bolt (see Appendix D), and spaced three inches apart to allow for foundation movement and attachment. The spacing of the sub-foundation mounting base hole location shown in Figure 21 may not necessarily be in the optimum location for universal adaptation and is currently being evaluated for hole placement by the MIWG.

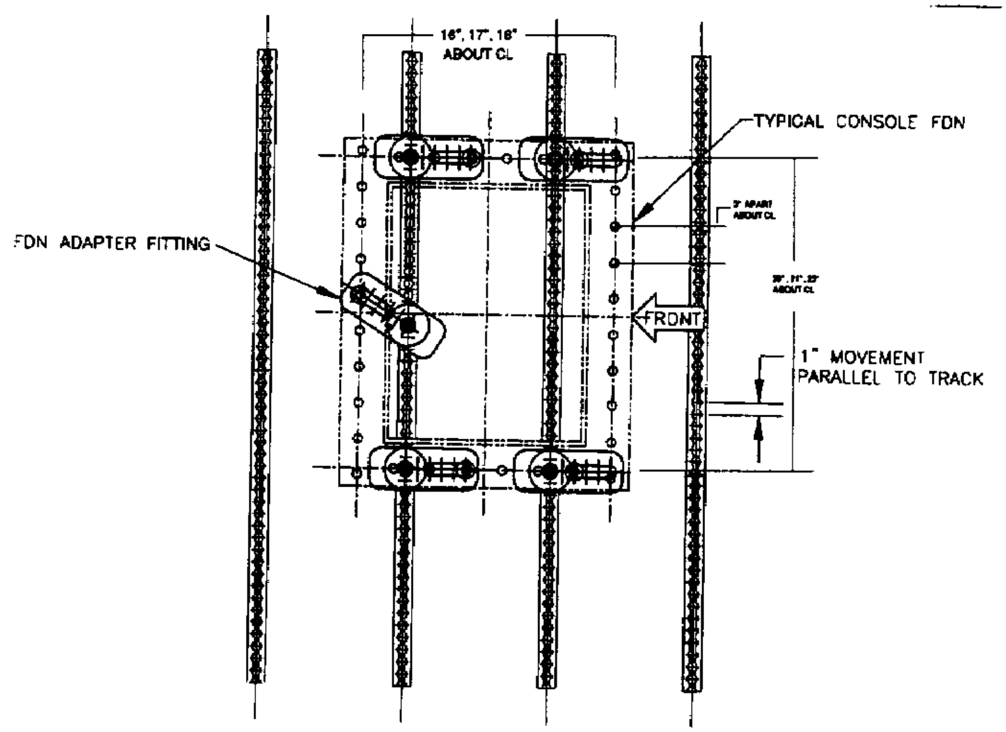


Figure 21: Typical Sub-Foundation Mounting Hole Location Foundation.

2.9 Flat Plate Foundation

A flat plate foundation may be applicable for some installations where height is critical, and the equipment rack or console is classified as light or medium weight. Each square foot of loading shall be evaluated to determine the stress applied to the plate. Where there is not excessive loading, the plate foundation may be utilized. The LHA's Command Table installation is a prime application, because the foundation mounting holes are not in alignment with the foundation track and height is critical (see Figure 22). The plate material must be determined and sized to suit the requirement. The NNSY design for the LHA Command Table uses a 10.2 lb. plate cut to suit the footprint, and 3/8 inch studs are welded to the top of the foundation plate. The Command Table will be bolted to these studs. Holes will be drilled through the foundation plate as required to allow bolting the assembly to the track (see Figure 23). Care must be taken to align the plate with the rabbet edge of the deck panels when overlapping the track. This method has several drawbacks: 1) the plate mounting holes are applicable to a single application, and 2) it is limited by weight. The goal of relocating a foundation without physical modifications is not always practical which should be a consideration when deciding whether or not to use this design. If this design is chosen, then the flat plate foundation should be designed to accommodate the maximum amount of flexibility that the application will allow.

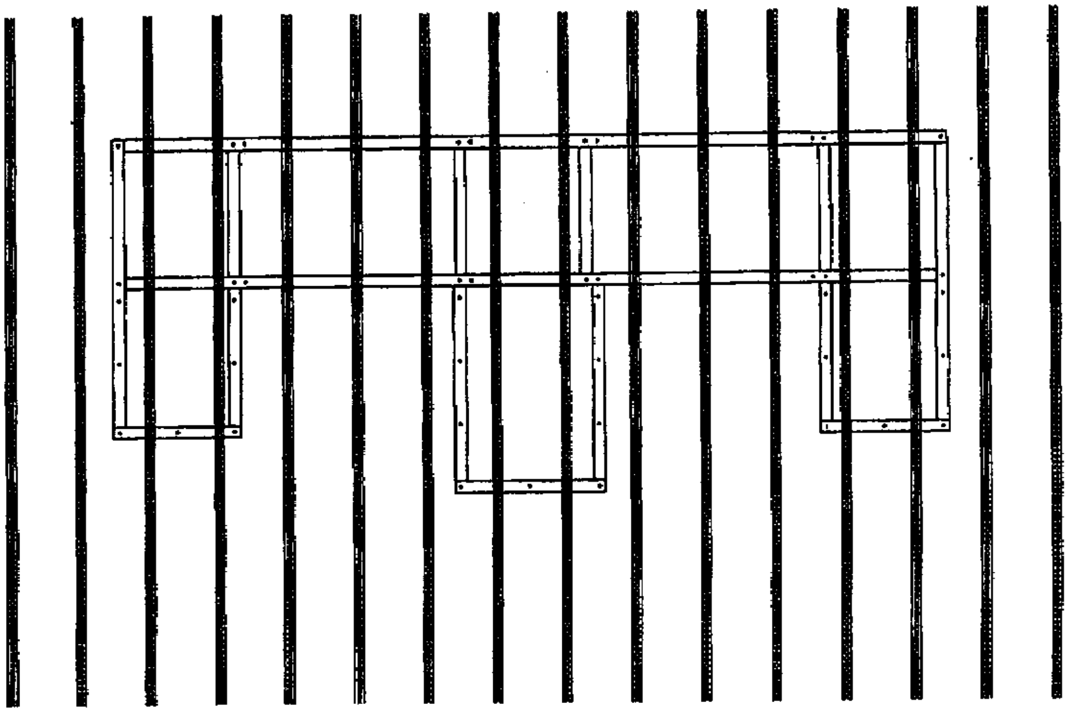


Figure 22: Typical Foundation Mounting Holes Command Table.

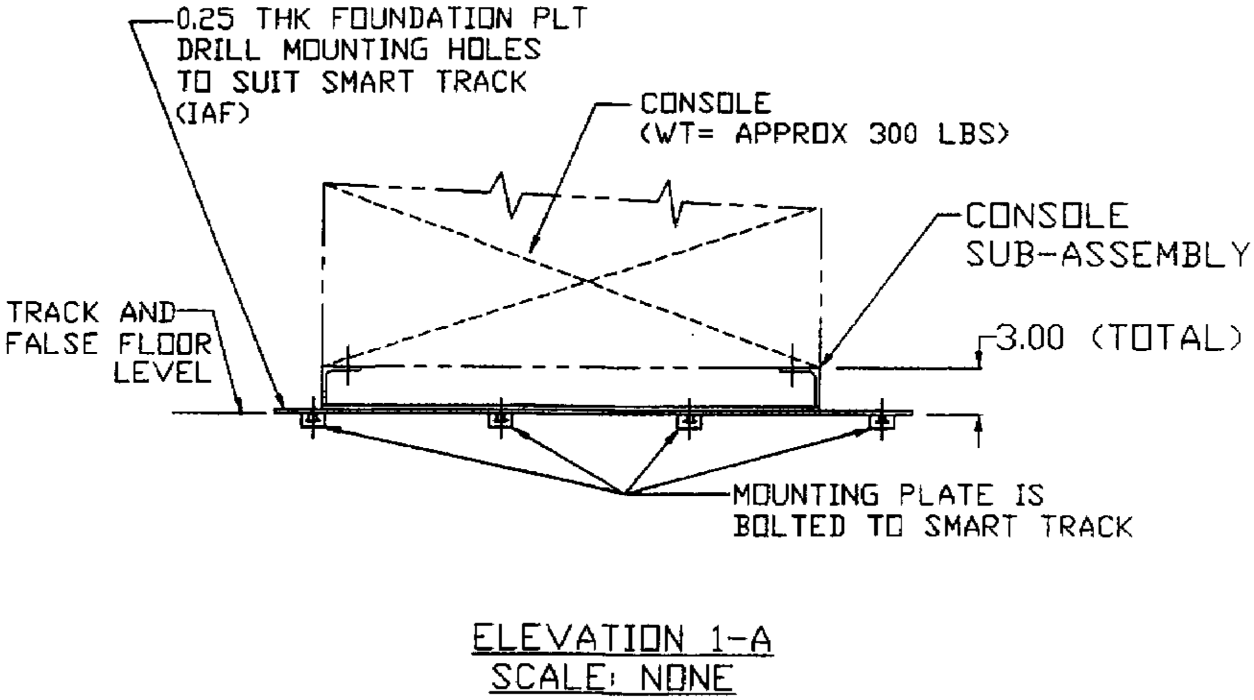


Figure 23: Typical Foundation Tactical Display Console.

2.10 Modular Foundations - Conclusion

PMS335T's agenda is to reduce the production and installation costs by providing a standardized design and drawing for a SMART Foundation. Finding a single approach to the foundation issue for SMART overhaul of U.S. Navy ships is not a simple task. Multiple approaches, as applicable by the design shipyard, are recommended by the MIWG. During the SMART development phase, many designs were viewed in an attempt to find one universal foundation. It was determined that there must be some flexibility, in that one method will not meet all the installation requirements and cost sensitivity. The MIWG was forced to concentrate on SMART for overhaul of U.S. Navy Surface Ships. New construction will be addressed in the near future.

The primary goals of rapid installation and reconfiguration without any modification on the track, fitting, and foundation have been demonstrated by use of the modular adapter fitting and sub-foundation. There are areas that will require some modification. One of these areas is the deck panels. The false deck panels will be the only mechanical or physical entity that is a non-electrical item that would need to be cut to fit as spaces are reconfigured.

There are five basic types of foundations: (1) the fixed or hard (universal) foundation, (2) the adjustable column support, (3) the basic flat plate, (4) the adapter fitting with sub-foundation, and (5) the sub-foundation.

2.10.1 Modular Adapter Fitting

The only design that meets all the goals (vertical adjustment requirement succeeds by use of the "Modular False Deck Frame" design) is the adapter fitting. The adapter is light weight and the stocking size is efficient for spares to be carried onboard. The system provides unlimited lateral, transverse, and angular placement of equipment, readily accepts an equipment sub-foundation, and uses standard hardware for mounting. The adapter fitting is recommended by the MIWG for use as a total SMART System.

2.10.2 Universal Foundation (Hard Foundation)

The universal foundation and foundation systems with false decks are both referred to as hard foundations. The system resembles a traditional system, except it is track mounted. The hard foundation has application, for example, onboard the LCC 19. The SACC command space utilizes a soft track system for the light weight 24" workstations, however, there are a few racks that require a heavier foundation. PSNS Det Boston's adaptation of the hard foundation as a stand-alone system proved to be the most efficient approach, and should be considered in such situations. The approach should be similar to the design shown in Figure 5.

2.10.3 Flat Plate Foundation

Although this approach is neither innovative nor recommended due to its lack of universal or reusable application; except where other concepts will not meet the requirements. This approach used for the Command Table onboard the LHA Class meets the design requirements for a low-profile mounting. This approach provides the low-profile mounting required for the Command Table to meet the height requirements for placement of the large screen displays, matches the equipment mounting holes, and provides for track attachment.

2.10.4 Sub-Foundation (Equipment/Track Interface)

There have been numerous discussions within the MIWG concerning a universal sub-foundation (one sub-foundation that fits all). The MIWG has made every effort to design a single foundation. The working groups evaluation of the current workable designs has resulted in the committee recommending a sub-foundation or interface foundation that works in conjunction with the modular track adapter fitting. The equipment interface foundation must be unique for each equipment rack or console for the reasons explained in Section 2.8. However, each sub-foundation is designed once to interface with a rack, cabinet or console footprint that is unique to that equipment and becomes a type drawing for all other C4I SMART applications of that particular piece of equipment. This meets the requirements of a manufacturer's cabinet, or console design for grade A shock, vibration, weight, and access to the mounting holes, and sizes the hardware as required. The sub-foundation takes into consideration that no two cabinets have the same dimensional footprint. Therefore, the MIWG recommends the design of a sub-foundation be structurally sound to withstand the specified vertical and shear forces at the critical points of stress, maintaining the smallest footprint possible for weight and space reduction.

Appendix A

Conventional Foundation Report

Norfolk Naval Shipyard
Engineering and Planning Department
Engineering Division

252-XX-95
20 Oct 1995

Memorandum

From: Code 252

Subj: AFFORDABILITY THROUGH COMMONALITY (ATC) EQUIPMENT FOUNDATION STUDY

Ref: (a) NAVSEA ltr ser 335TW/9033 dtd 13 January 1995

1. Per ref (a), NNSY was tasked to perform an extensive survey of equipment foundations on all classes of ship for which it serves as planning yard. The goal of this survey was to evaluate, quantify, and validate the numerous equipment foundations currently found on naval vessels. The information gathered by this survey would be inputted into an electronic Database established by NNSY which, in turn, may be used by other Installing activities (SPAWAR, NICE East, other planning yards, etc.) to expand the Foundation survey to include ships and equipment under their cognizance. NNSY has selected Foxpro by Microsoft to manage and maintain the foundation database.

2. In order to provide the most useful information, NNSY considered equipment foundations located in C4I spaces on CVN-68 Class, LHA-1 Class, and LHD-1 Class ships. The study was defined to include only the C4I spaces on these classes of ships which were possible candidates for C4I modular "SMART" track installation, i.e. spaces which experience a high turnover of equipment where a C4I modular "SMART" track would facilitate the removal, reinstallation, and rearrangement of equipment.

3. The project began by interviewing the NNSYproject leaders for the CVN, LHA, and LHD Class ships to determine which C4I spaces met the requirements for a future C4I modular "SMART" track system installation. The criteria used to determine possible candidates included an examination of the past history of the space in regards to frequency of equipment turnover and also any future changes that are known to be scheduled for that space. Based on these requirements, the following spaces were selected:

CVN-68 CL	LHA-1 CL	LHD-1 CL
CIC (03-160-0-C)	CIC (06-65-3-C)	CIC (02-65-0-C)
CVIC ADP Area (03-133-2-C)	TACC (06-73-3-C)	TFCC (02-70-0-C)
CVIC ASW Area (03-156-1-C)	Flag Plot (05-65-1-C)	
Comm Center (03-108-0-C)		
TFCC (03-156-1-C)		

4. Equipment arrangement drawings for each of these spaces were located and compiled to reflect the most up-to-date arrangement. The foundation drawings for each of the major pieces of equipment located within the spaces were then found and the data was incorporated into the foundation database (see attached chart). The chart is a report generated by Foxpro comparing various foundation information within and across ship classes.

5. One of the main purposes of this study was to quantify costs (design, prefab, and installation) associated with equipment foundations. Results of the study indicate that representative cost for a small foundation (less than 30 manhrs to prefab), a medium foundation (30 to 60 manhrs to prefab), and a large foundation (more than 60 manhrs to prefab) can be summarized as follows:

	Design Cost	Prefab Cost	Installation Cost	Total
Small (Example: Display Console OA-7979/UYA-4(v))	4 Manhours	21 Manhours	28 Manhours	53 Manhours
Medium (Example: Recorder/Reproducer)	8 Manhours	36 Manhours	44 Manhours	88 Manhours
Large (Example: Recorder/Reproducer RD-379(V)UNH)	8 Manhours	83 Manhours	110 Manhours	201 Manhours

In addition, while the future material costs required to fabricate an average foundation will likely stay the same, the future costs associated with labor (prefab and installation) will increase as the average manday rates increase.

6. Further, results of the study also revealed that foundation designs are rarely shared across ship classes and often times not even within ship classes. Some of the possible reasons why foundation designs are not shared include differences in hull material (aluminum or steel), minor differences in space arrangements, and differences in foundation size driven by the need to land on available backing structure.

SHIPNAME	SPACE	EQPT_NAME	EQPT SYS	DWG_WTGRP	DWG_NUM	COST_DESGN	COST FAB	COST_INSTL	COST_MATL	WEIGHT	MATL	REMARKS
George Washington	COMM CENTER (03-108-0-C)	AN/UGC-143A(V)4		113	6294622	4	19	37		40	1	3 Units, 3 Foundations
George Washington	COMM CENTER (03-108-0-C)	SA-2112A(V)6/STQ		113	6293663	8	31	43	60	35	1	
Wasp	CIC (02-65-0-C)	TT-624D(V)2/UG	MISC COMM SYS	184	5863405	4	29	38	360	107	1	
Wasp	TACC (02-70-C)	TT-624D(V)9/UG	MISC COMM SYS	184	6208340	8	29	23	360	105	1	
Wasp	CIC (02-65-0-C)	MK 86 NSSMS	MK 86	184	5863289	4	70	76	600	70	1	
Wasp	CIC (02-65-0-C)	CY-7734/SSQ-82(V)	AN/SSQ-82(V)	184	6941416	8	32	31	420	90	1	
Wasp	CIC (02-65-0-C)	TAO EQPT GROUP		184	5863289	8	70	76	600	132	1	
Wasp	CIC (02-65-0-C)	TAL/AIC CONSOLE GROUP		184	5863289	4	70	76	660	66	1	
Wasp	CIC (02-65-0-C)	DATA TERMINAL GROUP		184	5863289	8	66	57	600	130	1	
Wasp	CIC (02-65-0-C)	CONTROL MONITOR GROUP		184	5863289	4	91	88	780	100	1	
Wasp	CIC (02-65-0-C)	RCO/PDWC CONSOLE GROUP		184	5863289	4	91	88	600	100	1	
Wasp	CIC (02-65-0-C)	SD/T CONSOLE GROUP		184	5863289	8	71	76	600	130	1	
Wasp	CIC (02-65-0-C)	EWD/EWS CONSOLE GROUP		184	5863289	4	75	76	600	140	1	
Wasp	CIC (02-65-0-C)	CSCP MK 328 MOD	MK 328	184	6505960	4	39	24	360	86	1	
Wasp	CIC (02-65-0-C)	DRT MK 6 MOD 4C	MK 6	184	5863182	8	42	22	420	225	1	
Wasp	CIC (02-65-0-C)	OJ-684(V)1 /USQ-119(V)	AN/USQ-119(V)	184	6941416	8	84	72	600	165	1	w/ Sway Brace
Wasp	CIC (02-65-0-C)	HP-3630A		184	6941416	8	30	23	360	225	1	
Wasp	TACC (02-70-C)	AN/USQ-69B(V)	AN/USQ-69	184	6208339	8	110	84	660	63	1	Bulkhead mounted
Wasp	CIC (02-65-0-C)	PT-525(V)/UYQ-21 (V)	AN/UYQ-21(V)	184	5863351	8	84	48	660	370	1	2 Units, 2 Foundations
Wasp	CIC (02-65-0-C)	RD-390(V)/UNH		184	6208347	8	49	50	480	75	1	w/ Sway Brace
Wasp	CIC (02-65-0-C)	IP-1243/UYK		183	6125588	8	28	26	480	50	1	
Wasp	CIC (02-65-0-C)	OJ-557(V)2/USQ-88(V)	AN/USQ-88(V)	184	5863186	4	32	38	420	89	1	
Wasp	CIC (02-65-0-C)	OA-9154(V)12/USG-58(V)	AN/USG-58(V)	184	5863187	4	32	41	420	100	1	
Wasp	CIC (02-65-0-C)	ESPIRIT 2000G	NTCSA	184	6941416	8	32	40	420	185	1	
Wasp	TACC (02-70-C)	OJ-535(V)2/UYQ-21(V)	AN/UYQ-21 (V)	184	5863387	8	29	41	300	77	1	
Wasp	TACC (02-70-C)	ASC/CAS CONSOLE GROUP		184	5863286	16	86	103	600	25	1	3 Consoles, 3 Foundations
Wasp	TACC (02-70-C)	AWC/ATC CONSOLE GROUP		184	5863286		58	71	550		1	
Wasp	TACC (02-70-C)	HELICOPTER CONTROL CONSOLE GROUP		184	5863286	16	70	85	540	25	1	2 Consoles, 2 Foundations
Wasp	TACC (02-70-C)	PT-533		184	6208340	4	36	30	420	105	1	
Wasp	TACC (02-70-C)	RD-379(V)/UNH		184	6208341	4	34	32	420	130	1	w/ Sway Brace
George Washington	COMM CENTER (03-108-C)	A & J RACK, 72-150		113	6946721	4	17	41	60	30	1	Rack associated with AN/USC-38(V)2 EHF SATCOM
George Washington	COMM CENTER (03-108-C)	CU-2007/SRR		113	6293663	4	31	15	60	75	1	
George Washington	COMM CENTER (03-108-C)	SB 863/SRT		113	6293663	8	23	35		172	1	
George Washington	COMM CENTER (03-108-C)	AN/USQ-69(V)		113	6294622	4	16	11		150	1	
George Washington	COMM CENTER (03-108-C)	AN/UGR-9		113	6294622	8	102	33		170	1	3 Units, 3 Foundations
George Washington	COMM CENTER (03-108-C)	AN/UYK-20X(V)		113	6294821	4	16	14		90	1	
George Washington	COMM CENTER (03-108-C)	MAINCOMM WORKSTATION	NAVMACS II	113	7036369	8	70	99		136	1	6 Units, 6 Foundations
George Washington	COMM CENTER (03-108-C)	AN/SYQ-7A(V)	NAVMACS II	113	7036369	4	20	36		75	1	
George Washington	TFCC	OJ-535(V)12/UYQ-21 (V)		113	6296181	8	26	29	90	105	1	
George Washington	TFCC	TFCC CONSOLE	NTCS-A	613	6160519	16	144	67	450	1300	1	
George Washington	TFCC	IP-1384/SPS-25	RADDS	113	6946741	8	48	122	120	50	1	
George Washington	TFCC	HP LASERJET PRINTER	NTCS-A	113	6946741	8	34	15		75	1	
George Washington	CVIC - ADP AREA	PT-540(V)1/U	ASWM	113	6015259	8	20	34		70	1	
George Washington	CVIC - ASW ANALYSIS AREA	OJ-617(V)1/UQX-5(V)	ASWM	113	5942104	8	83	167	295	300	1	
George Washington	CVIC - ASW ANALYSIS AREA	R-2088A/SKR-6	AN/SKR-6, ASWM	113	5942104	8	28	55	100	45	1	
George Washington	CVIC - ASW ANALYSIS AREA	TS-3683A/SKR-6	AN/SKR-6, ASWM	113	5942104	8	28	42	72	45	1	
George Washington	CVIC - ASW ANALYSIS AREA	BOW MODEL 122N	ASWM	113	5942104	8	28	42	72	50	1	
George Washington	CVIC - ASW ANALYSIS AREA	OJ-451(V)3/UYQ-21 (V)	ACDS	113	5942104	8	17	19	70	50	1	
George Washington	CVIC - ASW ANALYSIS AREA	OJ-535(V)3/UYQ-21 (V)		113	5942104	8	28	35		60	1	2 Units, 2 Foundations
George Washington	CIC	OJ-451(V)9/UYQ-21 (V)	ACDS	113	5942106	4	72	68		150	1	3 Units, 3 Foundations
George Washington	CIC	OJ-535(V)3/UYQ-21 (V)	ACDS	113	5942107	8	18	19		45	1	
George Washington	CIC	OJ-451(V)9/UYQ-88	ACDS	113	5942105	4	48	48		100	1	2 Units 2 Foundations
George Washington	CIC	OJ-684(V)/USQ-119A(V)	NTCS-A	113	5942108	4	48	41		100	1	
George Washington	CIC	OJ-683(V)/USQ-119A(V)	NTCS-A	113	5942108	8	48	41		90	1	
George Washington	CIC	PT-525A/UYQ-21 (V)		113	5942107	4	31	72		80	1	2 Units 2 Foundations
George Washington	CIC	AWC OFFICER CONTROL PAN	ACDS	113	5942107	8	28	38		120	1	
George Washington	CIC	CIWS MK 340 MOD 4CIWS		113	5942107	8	65	62		130	1	
Tarawa	FLAG PLOT	AZIMUTH RANGE INDICATOR		113	4522086	4	29	30	168	100	1	
Tarawa	FLAG PLOT	ITAWDS DISPLAY CONSOLE		113	4522086	4	12	28	96	25	1	
Tarawa	TACC	ENTRY QUERY CONTROL CONSOLE		113	4415265	8	38	32	240	80	1	

SHIPNAME	SPACE	EQPT_NAME	EQPT SYS	DWG_WTGRP	DWG_NUM	COST_DESGN	COST FAB	COST_INSTL	COST_MATL	WEIGHT	MATL	REMARKS
Tarawa	TACC	OJ-195/UYA-4(V)	AN/UYA-4(V), ITA	113	4415265	16	96	163	576	250	1	6 Units, 6 Foundations
Tarawa	TACC	RC-3212	ATCC-DAIR	113	6942619	8	24	37	120	50	1	w/ Sway Brace
Tarawa	TACC	OD-201/TPX-42A(V)	ATCC-DAIR	113	6942619	8	29	30	180	40	1	
Tarawa	CIC	TERMINAL TY 1B		113	4522058	8	17	32	90	27	1	
Tarawa	CIC	OJ-446(V)/SLQ-32	SLQ-32	113	5289220	8	42	36	480	100	1	
Tarawa	CIC	DIGITAL DISPAY RACK		113	5289220	8	42	36	480	100	1	Rack includes: Display Console (OJ-446/SLQ-32), Wind Direction & Speed Indicator
Tarawa	CIC	MISC EQPT RACK		113	5289220	8	42	36	480	100	1	Rack includes: Digitial Display Indicator/Intercom Station/Digital Data Intro
Tarawa	CIC	DRT CABINET	NAVIGATION	113	4522058	8	19	40	180	30	1	Rack includes: Video Decoder [KYX57(P)/UPA-59(V)], EMI Supression Filter, and Amp (AM-37291SR)
Tarawa	CIC	TAO CONSOLE	ITAWDS	113	6062582	8	14	9	120	50	1	
Tarawa	CIC	DJ-683A(V)2/USQ-119A(V)	NTCS-A	113	6177948	8	22	32	150	30	1	
Tarawa	CIC	OJ-194(V)3/UYA-4(V)	SPS-48E RADAR	113	6946944	8	27	24	40	20	1	2 Units, 2 Foundations
Tarawa	CIC	CD-535	SYS-ZA MSITS	113	6946944	8	27	24	40	25	1	
Tarawa	CIC	OA-7979/UYA-4(V)	ITAWDS	113	6946944	8	27	24	40	25	1	
Tarawa	CIC	MK 113 MOD 2	MK-86	113	6058454	8	29	62	360	50	1	
Tarawa	CIC	MK 67 MOD 7	MK-86	113	6058454	8	20	30	240	30	1	2 Units, 2 Foundations
Tarawa	CIC	MK 340 MOD 2	CIWS	113	6061871	8	67	62	576	200	1	
Tarawa	CIC	MK 406 MOD 0	RAM	113	6058467	8	36	62	384	125	1	
Tarawa	CIC	CHAIR	FURNITURE	113	6058492	4	24	55	240	20	1	2 Units, 1 Foundation

Appendix B

C4I Modularity Foundations

C4I MODULARITY FOUNDATIONS

STEVEN CZARNY---NNSY

OBSERVATIONS:

(1) TRACK
(2) FALSE FLOORS
(3) FOUNDATIONS------------(a) MODULAR FOUNDATION ASSEMBLY
------------(b) UNIQUE UNIT INTERFACE FOUNDATION (INTERFACE FOUNDATION)

PROGRESS HAS BEEN MADE ON THE TRACK SYSTEM AND FALSE FLOOR SYSTEM, HOWEVER THERE SEEMS TO BE NO SURE DEVELOPMENT TOWARDS A "MODULAR" FOUNDATION ASSEMBLY THAT WILL WORK WITH <u>ANY</u> ELECTRONIC OR OTHER TYPE UNIT.

FOR FALSE FLOOR INSTALLATIONS: CONCEPTUAL SKETCHES FROM THE MEETINGS SEEM TO SHOW ONLY A BOLTED MODULAR FOUNDATION WHICH IS <u>STILL</u> UNIQUE TO THE EQUIPMENT BEING INSTALLED. IT CANNOT ACCEPT A SLIGHT SHIFT OR ROTATION IN LOCATION, WITHOUT A NEW FOUNDATION BEING BUILT.

TASK:

DESIGN AND ENGINEER A MODULAR FOUNDATION ASSEMBLY THAT MAY BE USED WITH THE CURRENT DESIGNED TRACK SYSTEM AND WILL BE ABLE TO BE USED WITH <u>ANY</u> PIECE OF EQUIPMENT TO BE MOUNTED.

FOUNDATION PROPOSAL FOR SYSTEMS WITH FALSE FLOORS:

SEE SKETCHES FOR MODULAR FOUNDATION ASSEMBLY

CONSTRUCTION: (STEEL)--3 "X 3" X 1/4" ANGLE LEGS
--20.4# (1/2") THICK TOP PLATE
--10.2# (1/4") THICK CHOCKS AND WEB PLATES
--20.4# (1/2") THICK FOOT PADS
--APPROXIMATE WEIGHT = 70 LBS

CONSTRUCTION: (ALUM)--3 "X 3" X 3/8" ANGLE LEGS
--(5/8") THICK TOP PLATE
--(3/8") THICK CHOCKS AND WEB PLATES
--(5/8") THICK FOOT PADS
--APPROXIMATE WEIGHT = 33 LBS

FEATURE: WEIGHT--THE INSTALLER SHOULD BE ABLE TO PHYSICALLY HANDLE THE ASSEMBLY.

FEATURE: ACTS AS AN INTERFACE BETWEEN THE TRACK SYSTEM AND THE "UNIQUE INTERFACE FOUNDATION" BELOW THE UNIT. THINK OF IT AS A "HARD SPOT".

FEATURE: SHOULD BE ABLE TO BE MOVED AROUND TO SUIT SHIFTS, RELOCATIONS OR ROTATIONS OF ELECTRONIC UNITS.

FEATURE: MUST BE COMPATIBLE WITH FALSE FLOOR SYSTEM.

FEATURE: NEEDS TO BE A COMMON AND SIMPLE ENOUGH DESIGN TO BE CONSIDERED A "SHELF ITEM" OR A STANDARD FOR THE MODULAR INSTALLATION SYSTEM.

FEATURE: CAN BUILD OUT OF STEEL OR ALUMINUM TO SUIT SHOCK REQUIREMENTS. LIGHTER EQUIPMENT MAY ONLY NEED AN ALUMINUM FOUNDATION, WHILE HEAVIER EQUIPMENT MAY REQUIRE THE STRONGER STEEL FOUNDATION.

FEATURE: THE UNIT INTERFACE FOUNDATION WOULD BE BOLTED TO THE MODULAR FOUNDATION IN A MANNER TO SUIT THE WEBS AND CHOCKS. BOLT LOCATIONS COULD BE SHIFTED TO SUIT.

FEATURE: ADDITIONAL WEIGHT IS ENCOUNTERED DUE TO THE "EXTRA" LEGS REQUIRED PER EACH MODULAR FOUNDATION UNIT, HOWEVER THE MODULAR CONCEPT BENEFIT OUTWEIGHS THE EXTRA WEIGHT CONSIDERATION.

FEATURE: LOOK AT A 6" X 24" (NOMINAL) ASSEMBLY TO MINIMIZE OVERLAP OF THE FOUNDATION (OVERLAP IS CONSIDERED TO BE THE PORTION OF THE MODULAR FOUNDATION NOT COVERED BY EQUIPMENT). OVERLAP SHOULD NOT BE A PROBLEM AS FALSE FLOOR SYSTEM MAKES UP SMOOTHLY TO IT. IF DECK WAS COVERED WITH ELECTRIC GRADE MAT, YOU WOULD NOT BE ABLE TO SEE OVERLAP ANYWAY.............THE 6" X 24" ASSEMBLY MIGHT NOT BE TO GREAT OF AN IDEA. READ ON.................MICKEY AMORENO AT NNSY SUGGESTS THE FALSE FLOOR SYSTEM MAY ALLOW FOR A PANEL OF THE SAME SIZE TO BE REMOVED AND A MODULAR FOUNDATION SET RIGHT IN ITS PLACE WITHIN THE SAME GRID TO CREATE A HARD SPOT. SOUNDS LIKE A GOOD POSSIBILITY AND SHOULD BE EXPLORED.

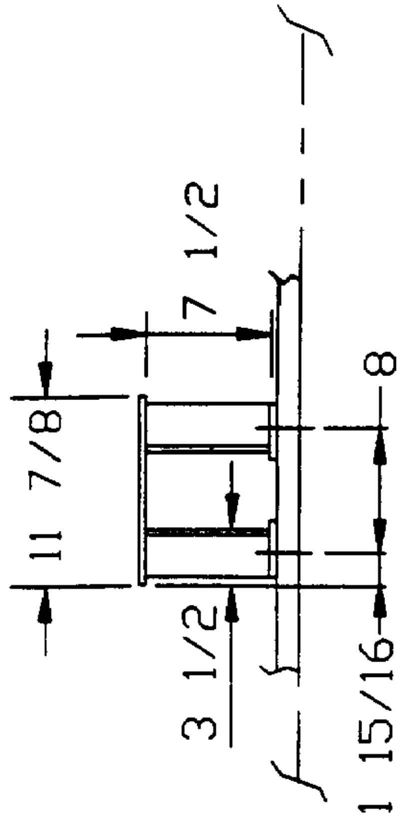
ENGINEERING REQUIRED:

(1) MUST LOOK AT INTERFACE WITH FALSE FLOOR SYSTEM.

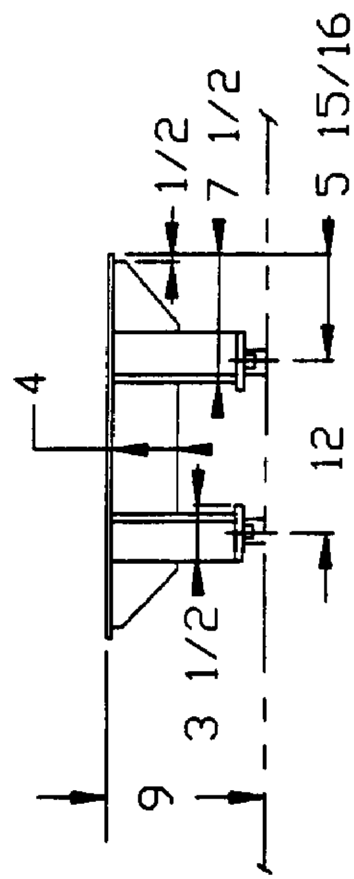
(2) PERFORM GRADE "A" SHOCK CALCULATIONS FOR ALUMINUM AND STEEL UNITS USING HIGHEST EXPECTED CABINET LOAD. OBTAIN ACDS EQUIPMENT WEIGHTS AS A STARTING POINT. POSSIBLE WORSE CASE WOULD BE TO LOAD THE MODULAR FOUNDATION WITH 2 BOLTS OUT OF ASSUMED 4, AND WITH ONE HALF THE ESTIMATED CABINET WEIGHT AND CENTER OF GRAVITY. LOCATE THE 2 BOLTS NEAR THE EDGE OF THE FOUNDATION.

FOUNDATION PROPOSAL FOR DECK SYSTEMS WITHOUT FALSE FLOORS:

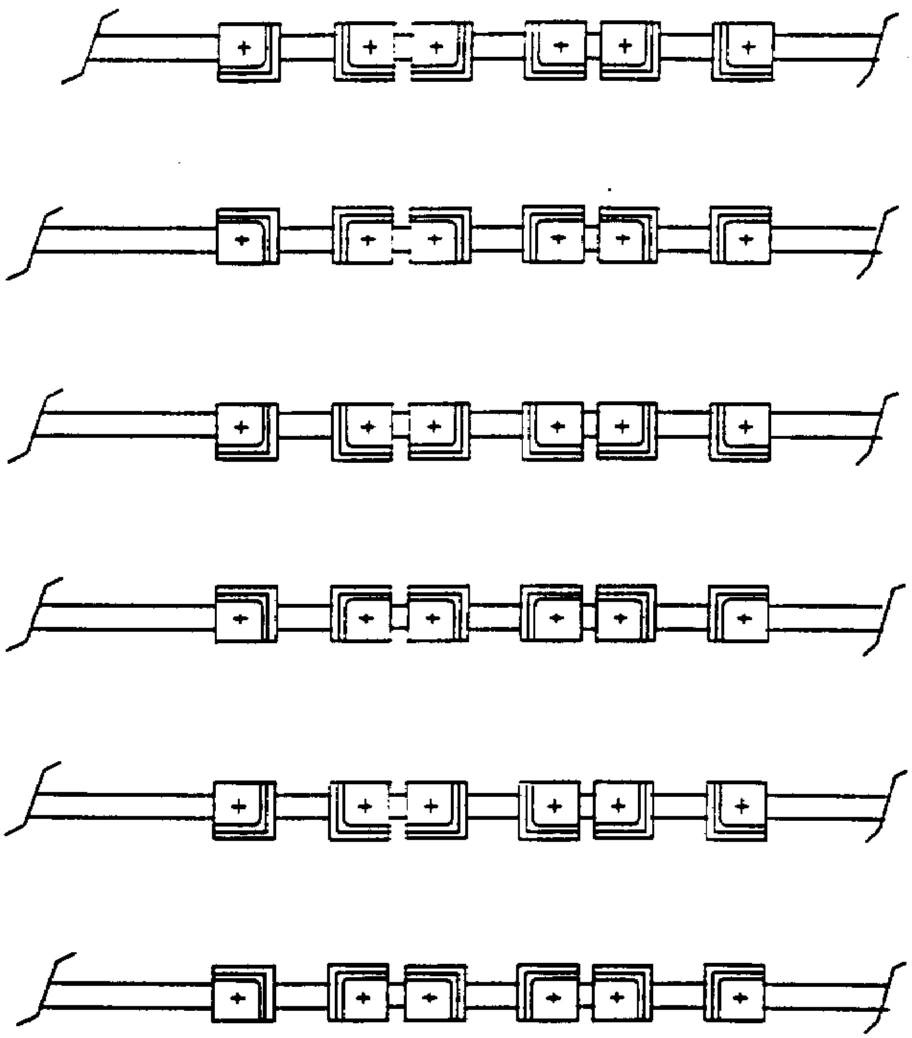
NOT YET DEVELOPED

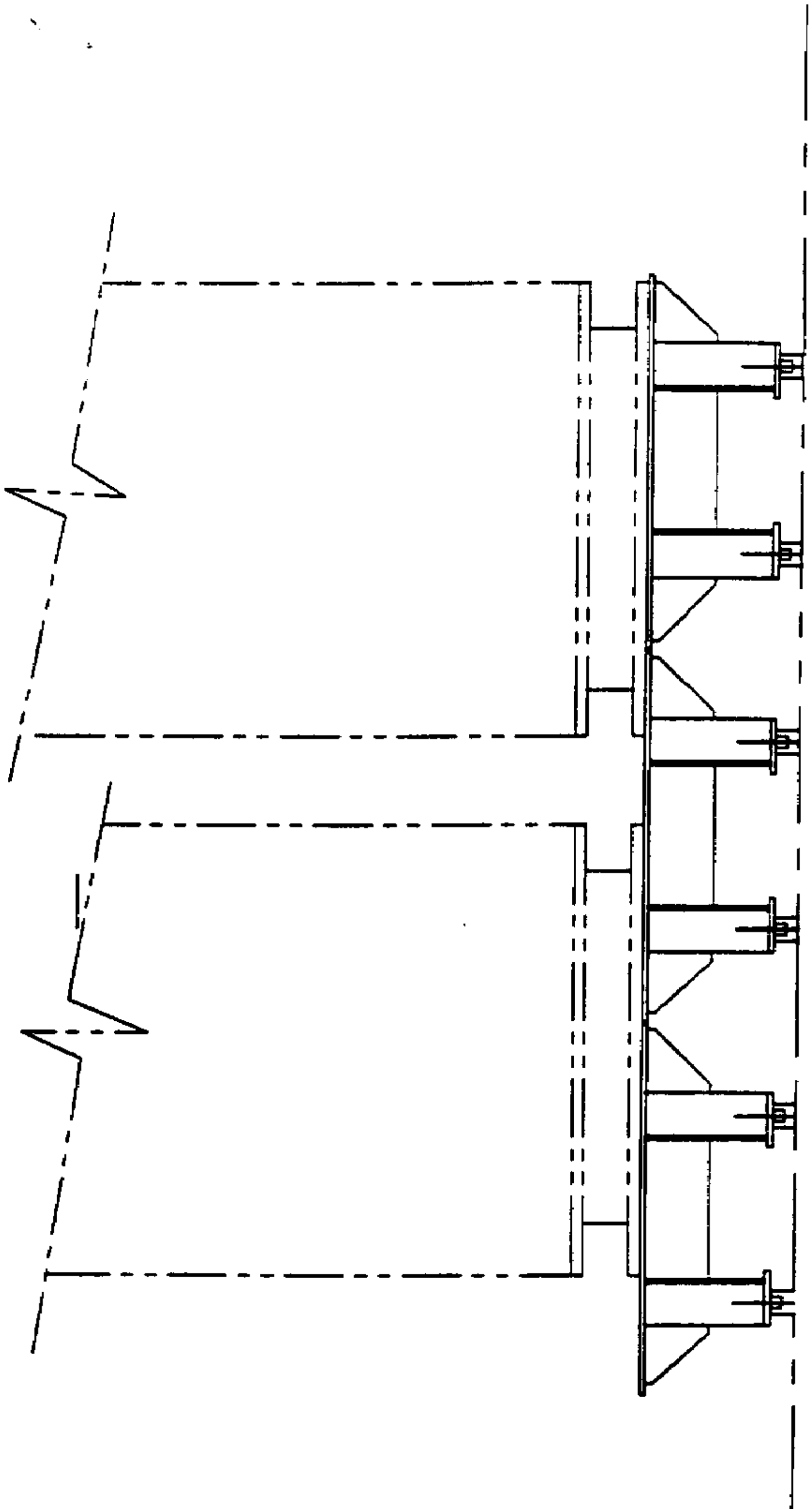


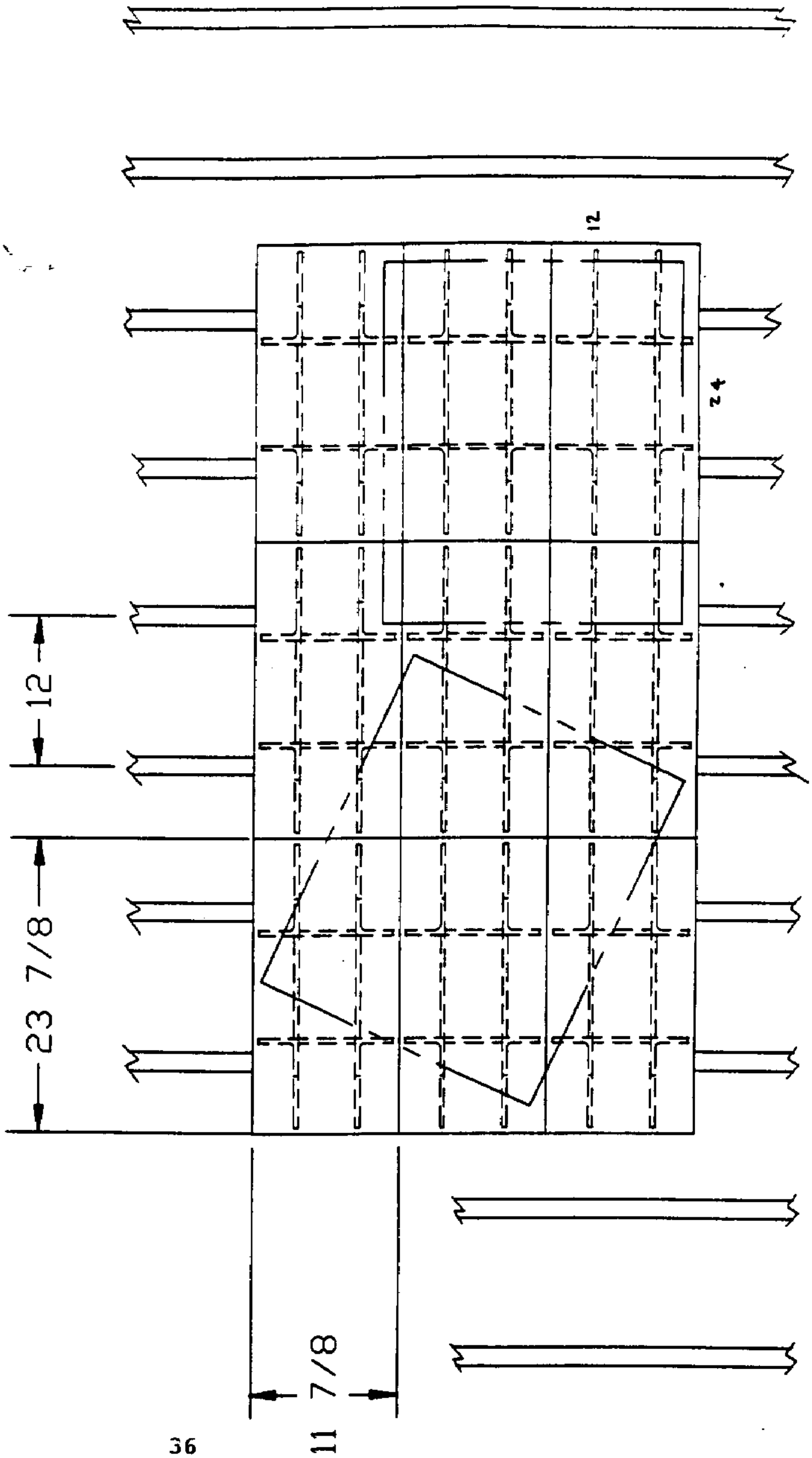
7 1/2
11 7/8
8
3 1/2
1 15/16



4
1/2
7 1/2
5 15/16
12
3 1/2
6






12
23 7/8
11 7/8
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24

Appendix C

C4I Modular Track Adapter Fitting Analysis

NORFOLK NAVAL SHIPYARD
ENGINEERING AND PLANNING DEPARTMENT
ENGINEERING DIVISION
PORTSMOUTH, VIRGINIA 23709-5000

C4I MODULAR TRACK ADAPTER FITTING ANALYSIS

SEPTEMBER 1994

C4I MODULAR TRACK ADAPTER FITTING ANALYSIS

A finite element analysis was performed to prove the structural integrity of a C4I modular track adapter fitting. This fitting is designed to provide an interface between various equipment foundations and either a medium or heavy duty C4I modular track fitting. I/FEM finite element modeling software by Intergraph was used to model and analyze the adapter fitting to determine exact dimensions and material requirements to support the expected loads in the grade A shock environment.

Figure 1 shows the dimensions of the adapter fitting. It was assumed the fitting would be manufactured from steel and several grades were examined. The following material properties were used for this analysis:

Table 1: Steel Material Properties

Grade	Yield Stress
OSS	34 ksi
HSS	47 ksi
HY-80	80 ksi
HY-100	100 ksi

Under Grade A shock, with elastic-plastic behavior permitted, stresses in structure must remain below 200% of yield. This requirement is in accordance with NAVSEA 0900-LP-097-4010 "Structural Design Manual for Naval Surface Ships" and with NAVSEA 0908-LP-000-3010 "Shock Design Criteria for Surface Ships".

The loads for this analysis are based on Table 2 of NAVSEA Technical Note No. 070-PMS335-TN-0011 "C4I Modular Track & Fittings Pull Test Report". For the heavy duty track fitting, this lists a load of 25000 lb in both vertical and horizontal directions. For the medium duty track fitting, the load is 12500 lb in both vertical and horizontal directions.

RESULTS

A shock analysis was performed, using Intergraph's I/FEM finite element modeling software, in vertical and both horizontal directions (see Figure 2 for loading conditions). In heavy duty cases, a 25000 pound load was applied. For the medium duty case, a 12500 lb load was applied. Because the vertical shock was the most severe for the heavy duty fitting this was the only condition considered for the medium duty load. Table 2 lists the resultant stresses and deflections. Figure 3 shows the exaggerated deflection under the vertical shock condition

Table 2: Stresses and Deflections Due to Shock

Direction	Max Stress (ksi)	Max Disp (in)
vertical, HD	113	0.11
across axis, HD	69	0.039
parallel to axis, HD	34	0.0036
vertical, MD	57	0.055

Based on these results, the track adapter fitting needs to be manufactured from HY-80 steel or an equivalent material to have sufficient strength to meet the demands of heavy duty use. For a medium duty application, the adapter fitting could be manufactured from HSS steel or an equivalent material.

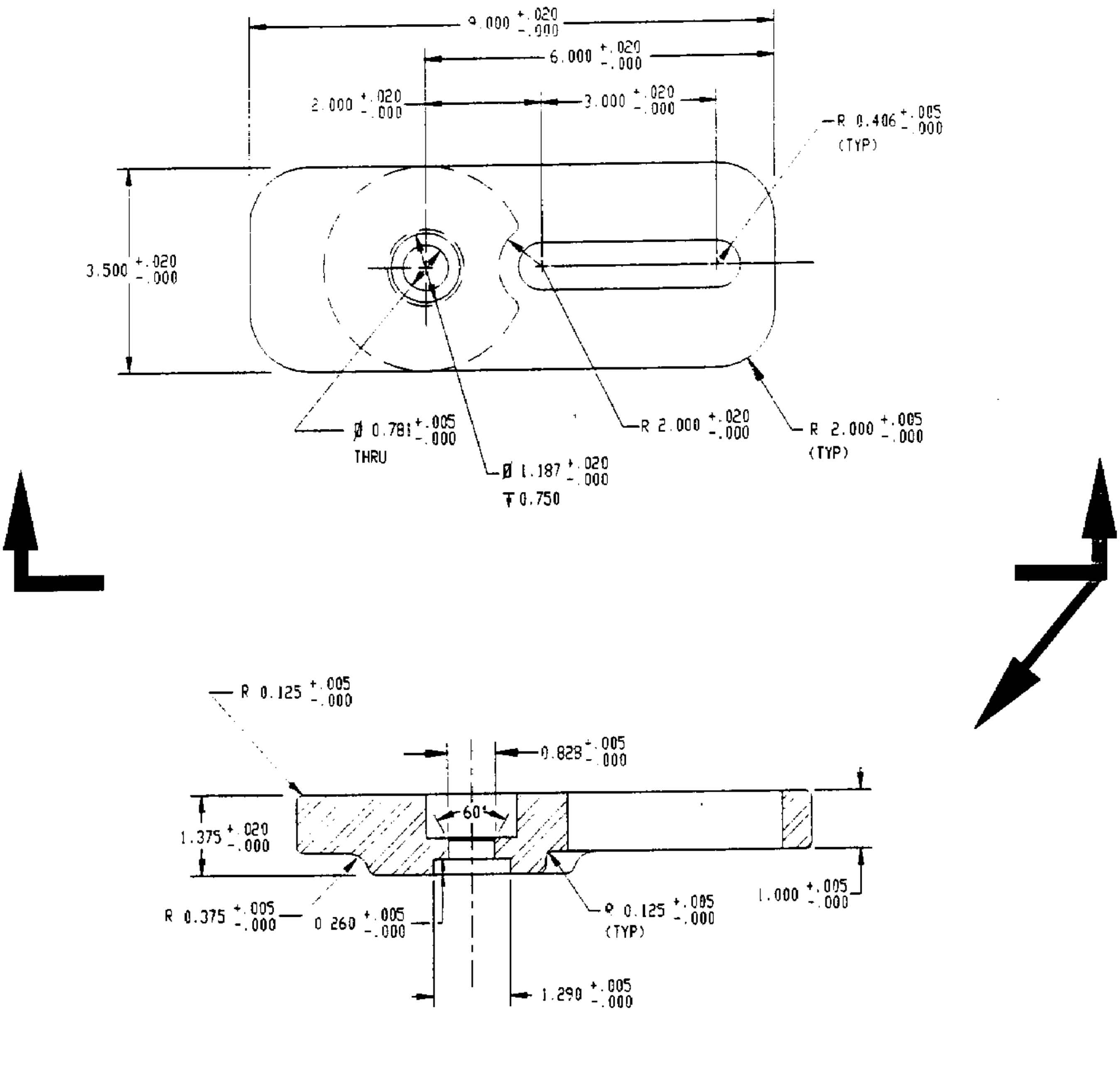


FIGURE 1 - DIMENSIONS OF TRACK ADAPTER FITTING

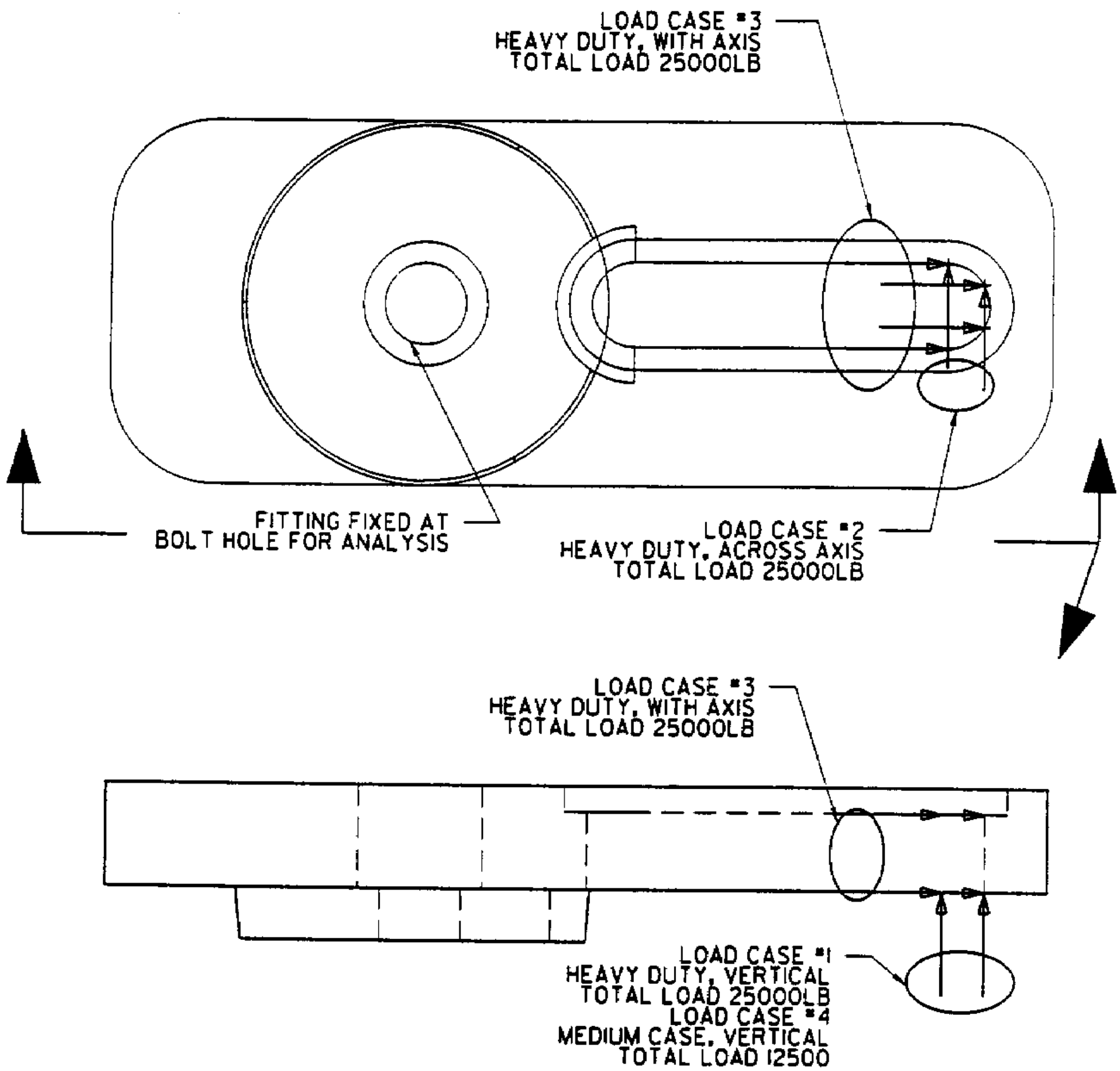


FIGURE 2 - LOADING OF TRACK ADAPTER FITTING FOR ANALYSIS

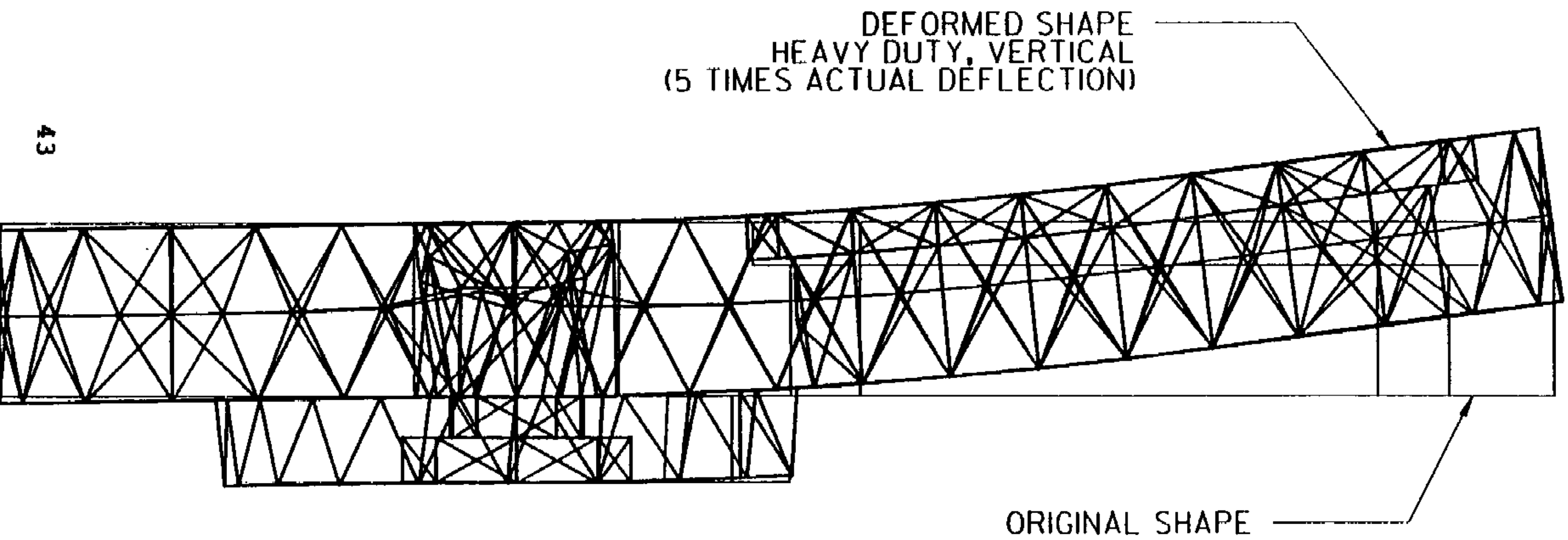


FIGURE 3 - DEFORMED SHAPE WITH HEAVY DUTY VERTICAL LOAD

POST DATA STATISTICS

Results Set Name : RS1
Description : Heavy Duty, Vertical
Date : 11Sep95 13:39

Post Node Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC1:DX	in	9.39e-03	1835	-1.72e-02	1847	1.72e-02	1847
LC1:DY	in	1.49e-03	1794	-1.11e-03	1855	1.49e-03	1794
LC1:DZ	in	1.09e-01	1841	-8.09e-03	1893	1.09e-01	1841
LC1:RX	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC1:RY	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC1:RZ	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC1:SXX	psi	1.10e+05	2185	-1.22e+05	1922	1.22e+05	1922
LC1:SYY	psi	3.95e+04	2141	-3.84e+04	1924	3.95e+04	2141
LC1:SZZ	psi	6.14e+04	2141	-2.93e+04	2059	6.14e+04	2141
LC1:SXY	psi	1.93e+04	2141	-2.48e+04	2135	2.48e+04	2135
LC1:SYZ	psi	2.89e+04	2141	-2.83e+04	2135	2.89e+04	2141
LC1:SZX	psi	5.89e+04	2134	-2.86e+04	2161	5.89e+04	2134
LC1:HVMSLD	psi	1.13e+05	2141	7.58e+02	2242	1.13e+05	2141
LC1:S1SLD	psi	1.35e+05	2141	-1.25e+05	1922	1.35e+05	2141
LC1:S2SLD	psi	3.79e+04	2134	-3.82e+04	1924	3.82e+04	1924
LC1:S3SLD	psi	2.19e+04	2185	-1.25e+04	2115	2.19e+04	2185
LC1:FX	lbf	1.95e+04	2160	-3.05e+04	2134	3.05e+04	2134
LC1:FY	lbf	6.38e+03	2135	-6.24e+03	2141	6.38e+03	2135
LC1:FZ	lbf	1.76e+04	2166	-2.66e+04	2163	2.66e+04	2163
LC1:MX	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC1:MY	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC1:MZ	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL

Post Elem Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC1:SXX	psi	2.10e+05	8471	-2.59e+05	7860	2.59e+05	7860
LC1:SYY	psi	7.80e+04	8121	-7.59e+04	7882	7.80e+04	8121
LC1:SZZ	psi	2.04e+05	8121	-1.86e+05	7882	2.04e+05	8121
LC1:SXY	psi	8.21e+04	7580	-6.45e+04	8002	8.21e+04	7580
LC1:SYZ	psi	4.40e+04	7958	-4.44e+04	8330	4.44e+04	8330
LC1:SZX	psi	9.58e+04	8282	-7.25e+04	8276	9.58e+04	8282
LC1:SEDSLD	ippcu	1.17e+03	7860	9.27e-03	6535	1.17e+03	7860
LC1:HVMSLD	psi	2.50e+05	7860	6.83e+02	6585	2.50e+05	7860
LC1:S1SLD	psi	2.35e+05	8471	-2.81e+05	7860	2.81e+05	7860
LC1:S2SLD	psi	7.97e+04	7831	-8.30e+04	7580	8.30e+04	7580
LC1:S3SLD	psi	6.93e+04	8121	-5.04e+04	7882	6.93e+04	8121
LC1:SEDNORM3D	ippcu	1.08e+03	7700	1.05e-02	6558	1.08e+03	7700

POST DATA STATISTICS

Results Set Name : RS2
Description : Heavy Duty, Across Axis
Date : 11Sep95 14:04

Post Node Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC2:DX	in	9.83e-03	1795	-1.01e-02	1878	1.01e-02	1878
LC2:DY	in	3.80e-02	1833	-5.51e-03	1903	3.80e-02	1833
LC2:DZ	in	8.88e-04	1844	-8.54e-04	1900	8.88e-04	1844
LC2:RX	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC2:RY	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC2:RZ	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC2:SXX	psi	5.80e+04	1789	-7.78e+04	2026	7.78e+04	2026
LC2:SYY	psi	3.55e+04	2027	-6.21e+04	2026	6.21e+04	2026
LC2:SZZ	psi	1.02e+04	2027	-1.17e+04	2184	1.17e+04	2184
LC2:SXY	psi	3.07e+04	2185	-2.44e+04	2140	3.07e+04	2185
LC2:SYZ	psi	1.35e+04	2134	-1.08e+04	2137	1.35e+04	2134
LC2:SZX	psi	1.09e+04	2136	-1.36e+04	2352	1.36e+04	2352
LC2:HVMSLD	psi	6.90e+04	2026	3.28e+02	1900	6.90e+04	2026
LC2:S1SLD	psi	6.50e+04	2027	-8.97e+04	2026	8.97e+04	2026
LC2:S2SLD	psi	3.12e+04	2141	-5.05e+04	2026	5.05e+04	2026
LC2:S3SLD	psi	8.56e+03	2184	-1.00e+04	2026	1.00e+04	2026
LC2:FX	lbf	2.21e+04	2160	-2.14e+04	2164	2.21e+04	2160
LC2:FY	lbf	1.51e+04	2166	-2.97e+04	2163	2.97e+04	2163
LC2:FZ	lbf	2.58e+03	2160	-2.11e+03	2165	2.58e+03	2160
LC2:MX	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC2:MY	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC2:MZ	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL

Post Elem Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC2:SXX	psi	1.09e+05	8774	-9.42e+04	8885	1.09e+05	8774
LC2:SYY	psi	5.93e+04	8788	-1.25e+05	8910	1.25e+05	8910
LC2:SZZ	psi	3.66e+04	8247	-4.73e+04	8559	4.73e+04	8559
LC2:SXY	psi	5.29e+04	7788	-4.27e+04	8009	5.29e+04	7788
LC2:SYZ	psi	4.04e+04	8121	-3.59e+04	7882	4.04e+04	8121
LC2:SZX	psi	5.83e+04	8128	-4.54e+04	8276	5.83e+04	8128
LC2:SEDSLD	ippcu	3.96e+02	8910	8.53e-04	6711	3.96e+02	8910
LC2:HVMSLD	psi	1.62e+05	8910	2.39e+02	6578	1.62e+05	8910
LC2:S1SLD	psi	1.13e+05	8774	-1.36e+05	8559	1.36e+05	8559
LC2:S2SLD	psi	5.98e+04	8910	-6.10e+04	8906	6.10e+04	8906
LC2:S3SLD	psi	3.27e+04	8247	-3.13e+04	8559	3.27e+04	8247
LC2:SEDNORM3D	ippcu	3.38e+02	8910	1.12e-03	6552	3.38e+02	8910

POST DATA STATISTICS

Results Set Name : RS3
Description : Heavy Duty, With Axis
Date : 12Sep95 7:58

Post Node Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC3:DX	in	3.45e-03	2067	-4.79e-05	2150	3.45e-03	2067
LC3:DY	in	9.68e-04	2079	-1.08e-03	1853	1.08e-03	1853
LC3:DZ	in	1.20e-03	1893	-1.10e-03	1920	1.20e-03	1893
LC3:RX	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC3:RY	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC3:RZ	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC3:SXX	psi	2.96e+04	2064	-1.41e+04	2028	2.96e+04	2064
LC3:SYY	psi	1.09e+04	1840	-1.07e+04	2028	1.09e+04	1840
LC3:SZZ	psi	4.94e+03	2029	-7.09e+03	2028	7.09e+03	2028
LC3:SXY	psi	8.05e+03	2020	-1.68e+04	2026	1.68e+04	2026
LC3:SYZ	psi	2.37e+03	2135	-2.75e+03	2141	2.75e+03	2141
LC3:SZX	psi	9.27e+03	2026	-4.47e+03	2138	9.27e+03	2026
LC3:HVMSLD	psi	3.36e+04	2026	2.23e+02	1898	3.36e+04	2026
LC3:S1SLD	psi	3.01e+04	2029	-1.83e+04	2028	3.01e+04	2029
LC3:S2SLD	psi	5.44e+03	2184	-1.88e+04	2026	1.88e+04	2026
LC3:S3SLD	psi	2.85e+03	2116	-6.02e+03	2028	6.02e+03	2028
LC3:FX	lbf	2.08e+03	2134	-4.91e+03	2164	4.91e+03	2164
LC3:FY	lbf	8.02e+02	2177	-8.32e+02	2135	8.32e+02	2135
LC3:FZ	lbf	2.81e+03	2163	-2.43e+03	2166	2.81e+03	2163
LC3:MX	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC3:MY	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC3:MZ	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL

Post Elem Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC3:SXX	psi	5.14e+04	8885	-6.94e+04	8910	6.94e+04	8910
LC3:SYY	psi	2.23e+04	8872	-2.61e+04	8911	2.61e+04	8911
LC3:SZZ	psi	2.71e+04	7882	-2.08e+04	8910	2.71e+04	7882
LC3:SXY	psi	1.38e+04	8881	-2.74e+04	8910	2.74e+04	8910
LC3:SYZ	psi	5.10e+03	8330	-3.96e+03	7958	5.10e+03	8330
LC3:SZX	psi	1.36e+04	8276	-9.08e+03	8479	1.36e+04	8276
LC3:SEDSLD	ippcu	9.96e+01	8910	2.88e-04	6539	9.96e+01	8910
LC3:HVMSLD	psi	7.33e+04	8910	1.39e+02	6539	7.33e+04	8910
LC3:S1SLD	psi	6.51e+04	8885	-7.99e+04	8910	7.99e+04	8910
LC3:S2SLD	psi	1.85e+04	8885	-2.08e+04	8910	2.08e+04	8910
LC3:S3SLD	psi	7.01e+03	8906	-8.73e+03	8899	8.73e+03	8899
LC3:SEDNORM3D	ippcu	9.84e+01	8903	4.10e-04	6562	9.84e+01	8903

POST DATA STATISTICS

Results Set Name : RS4
Description : Medium Duty, Vertical
Date : 12Sep95 11:08

Post Node Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC4:DX	in	4.70e-03	1835	-8.60e-03	1847	8.60e-03	1847
LC4:DY	in	7.47e-04	1794	-5.57e-04	1855	7.47e-04	1794
LC4:DZ	in	5.45e-02	1841	-4.05e-03	1893	5.45e-02	1841
LC4:RX	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC4:RY	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC4:RZ	SCALAR	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC4:SXX	psi	5.49e+04	2185	-6.11e+04	1922	6.11e+04	1922
LC4:SYY	psi	1.97e+04	2141	-1.92e+04	1924	1.97e+04	2141
LC4:SZZ	psi	3.07e+04	2141	-1.47e+04	2059	3.07e+04	2141
LC4:SXY	psi	9.64e+03	2141	-1.24e+04	2135	1.24e+04	2135
LC4:SYZ	psi	1.45e+04	2141	-1.41e+04	2135	1.45e+04	2141
LC4:SZX	psi	2.95e+04	2134	-1.43e+04	2161	2.95e+04	2134
LC4:HVMSLD	psi	5.65e+04	2141	3.79e+02	2242	5.65e+04	2141
LC4:S1SLD	psi	6.73e+04	2141	-6.27e+04	1922	6.73e+04	2141
LC4:S2SLD	psi	1.90e+04	2134	-1.91e+04	1924	1.91e+04	1924
LC4:S3SLD	psi	1.10e+04	2185	-6.27e+03	2115	1.10e+04	2185
LC4:FX	lbf	9.75e+03	2160	-1.53e+04	2134	1.53e+04	2134
LC4:FY	lbf	3.19e+03	2135	-3.12e+03	2141	3.19e+03	2135
LC4:FZ	lbf	8.80e+03	2166	-1.33e+04	2163	1.33e+04	2163
LC4:MX	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC4:MY	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL
LC4:MZ	in_lbf	0.00e+00	ALL	0.00e+00	ALL	0.00e+00	ALL

Post Elem Data

Data name	Unit	Max value	Occur uid	Min value	Occur uid	Max abs value	Occur uid
LC4:SXX	psi	1.05e+05	8471	-1.30e+05	7860	1.30e+05	7860
LC4:SYY	psi	3.90e+04	8121	-3.79e+04	7882	3.90e+04	8121
LC4:SZZ	psi	1.02e+05	8121	-9.29e+04	7882	1.02e+05	8121
LC4:SXY	psi	4.11e+04	7580	-3.23e+04	8002	4.11e+04	7580
LC4:SYZ	psi	2.20e+04	7958	-2.22e+04	8330	2.22e+04	8330
LC4:SZX	psi	4.79e+04	8282	-3.62e+04	8276	4.79e+04	8282
LC4:SEDSLD	ippcu	2.94e+02	7860	2.32e-03	6535	2.94e+02	7860
LC4:HVMSLD	psi	1.25e+05	7860	3.41e+02	6585	1.25e+05	7860
LC4:S1SLD	psi	1.17e+05	8471	-1.40e+05	7860	1.40e+05	7860
LC4:S2SLD	psi	3.98e+04	7831	-4.15e+04	7580	4.15e+04	7580
LC4:S3SLD	psi	3.47e+04	8121	-2.52e+04	7882	3.47e+04	8121
LC4:SEDNORM3D	ippcu	2.69e+02	7700	2.62e-03	6558	2.69e+02	7700

Appendix D

C4I Modularity: Modular Track Adapter Fitting
Drawing No. 113-7037309

PRELIMINARY

SHIP	REV	SHIPCK BY	DT
		N/A	

SHIP APPLICABILITY

DISTRIBUTION LIMITED TO D.O.D. & D.O.D. CONTRACTORS IN ORDER TO PROTECT CRITICAL TECHNOLOGY. OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED TO COMMANDER, NAVAL SEA SYSTEMS COMMAND (SEA09B2), WASHINGTON, DC 20362

NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VA
23709-5000

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C. 20362

PREPARED NNSY	DATE 8/95
CHECKED	
ENGINEER	
APPROVED	
~~ACCEPTED FOR NAVSEA~~	
APPROVED BY NAVSEA NOT REQUIRED	

C41 MODULARITY
MODULAR TRACK ADAPTER FITTING

MODULAR TRACK ADAPTER

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–

SCALE: AS SHOWN | C: CODE | SHEET 1 OF 9

PRELIMINARY

REVISIONS

REV	SHEET	DESCRIPTION	BY	DATE	APPROVED

PRELIMINARY

				N/A						
REV	SHIPALT NUMBER	WT GRP	WT (LBS)	I R XI OR XR	VCG REF BL	LCG REF ⊠	F OR A	TCG REF CL	P S OR 0	VAL BY

WEIGHT CONTROL DATA

LEVERS IN FEET TO THE NEAREST TENTH OF A FOOT
USE SEPARATE LINES FOR EACH WT GRP, S/A, REV, WT INSTL, WT RMV
I=INSTALL R=REMOVE XI=LOAD ITEM INSTALLED XR=LOAD ITEM REMOVED
F=FWD A=AFT P=PORT S=STBD 0=CL

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–
SCALE: NONE			SHEET 2	

PRELIMINARY

-	-	-	-	-	-	-	-	-
1	2	3	4	5	6	7	8	9

REVISION STATUS OF SHEETS

NO	HULL	TITLE	IDENT
7			
6	-	ENGINEERING CALCS - MODULAR TRACK ADAPTER FITTING	53711-XXX-XXXXXXX
5	-	HEAVY DUTY FITTING	53711-113-6904699
4	-	MEDIUM DUTY FITTING	53711-113-6904878
3	-	LIGHT DUTY FITTING	53711-113-2904879
2	-	ALUMINUM FOUNDATION TRACK	53711-113-6904880
1	-	STEEL FOUNDATION TRACK	53711-113-6904881

REFERENCES

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	-
SCALE: NONE			SHEET 3	

GENERAL NOTES

PRELIMINARY

1. THIS DRAWING WAS DEVELOPED INCIDENTAL TO ACCOMPLISHMENT OF THE C4I MODULARITY PROJECT.

2. THIS DRAWING IS BASED UPON THE REQUIREMENTS OF NAVSEA S9AA0-AB-GOS-010 (1990 EDITION) WHOSE PROVISIONS SHALL PREVAIL IN AREAS WHERE THIS DRAWING IS SILENT.

3. EXCEPT WHERE OTHERWISE NOTED OR APPROVED BY NAVSEA, THE EFFECTIVE DATE OF FEDERAL OR MILITARY SPECIFICATIONS, PUBLICATIONS AND STANDARD/TYPE DRAWINGS AND REVISIONS AND CHANGES THERETO SHALL BE THE EFFECTIVE DATE DEFINED IN NAVSEA S9AA0-AB-GOS-010 (1990 EDITION). LATER SPECIFICATION REVISIONS MAY BE USED PROVIDED THAT THEY MEET THE INTENT AND INTERFACE REQUIREMENTS OF THE SPECIFICATION INVOKED FOR THE SPECIFIC AVAILABILITY.

4. ENGINEERING DATA SUPPORTING THIS DRAWING IS FOUND ON REF 6.

5. THE PURPOSE OF THIS DRAWING IS TO PROVIDE FABRICATION DETAILS FOR AN ADAPTER FITTING TO BE USED WITH THE C4I MODULAR TRACK SYTEM (REF 1 THRU 5).

6. THE NUMBER AND LETTER IN PARENTHESES ( ) UNDER EACH VIEW DENOTES THE VIEW FROM WHICH IT WAS TAKEN.

7. AN ASTERISK (*) APPEARING OPPOSITE A REFERENCE DENOTES A REQUIRED REFERENCE. A REQUIRED REFERENCE IS ANY REFERENCE REQUIRED TO ACCOMPLISH INDUSTRIAL WORK AND ORDER MATERIAL.

GENERAL NOTES CONTINUED ON SHEET 5.

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–
SCALE: NONE				SHEET NO. 4

GENERAL NOTES (CONTINUED) PRELIMINARY

8. ABBREVIATIONS ARE IN ACCORDANCE WITH MIL-STD-12D EXCEPT AS FOLLOWS :
   OSS = ORDINARY STRENGTH STEEL (S) = STARBOARD (MR) = MODIFY/RELOCATE
   HSS = HIGHER STRENGTH STEEL (R) = RELOCATED (M) = MODIFIED
   IAF = INSTALLING ACTIVITY FURNISH GFM = GOVT. FURNISHED MATERIAL
   LLTM = LONG LEAD TIME MATERIAL CP = CENTRALLY PROCURED
   PM = PLATE MATERIAL U/I = UNIT OF ISSUE
   STRUCTURAL LEGEND: RIPOUT //////////////////////
   EXISTING ——— — — ——— NEW ———————

9. FABRICATION, WELDING, AND INSPECTION SHALL BE AS SPECIFIED ON THIS DRAWING, AND IN ACCORDANCE WITH MIL-STD-1689, REV A. SEE TEST NOTES FOR NDT REQUIREMENTS.

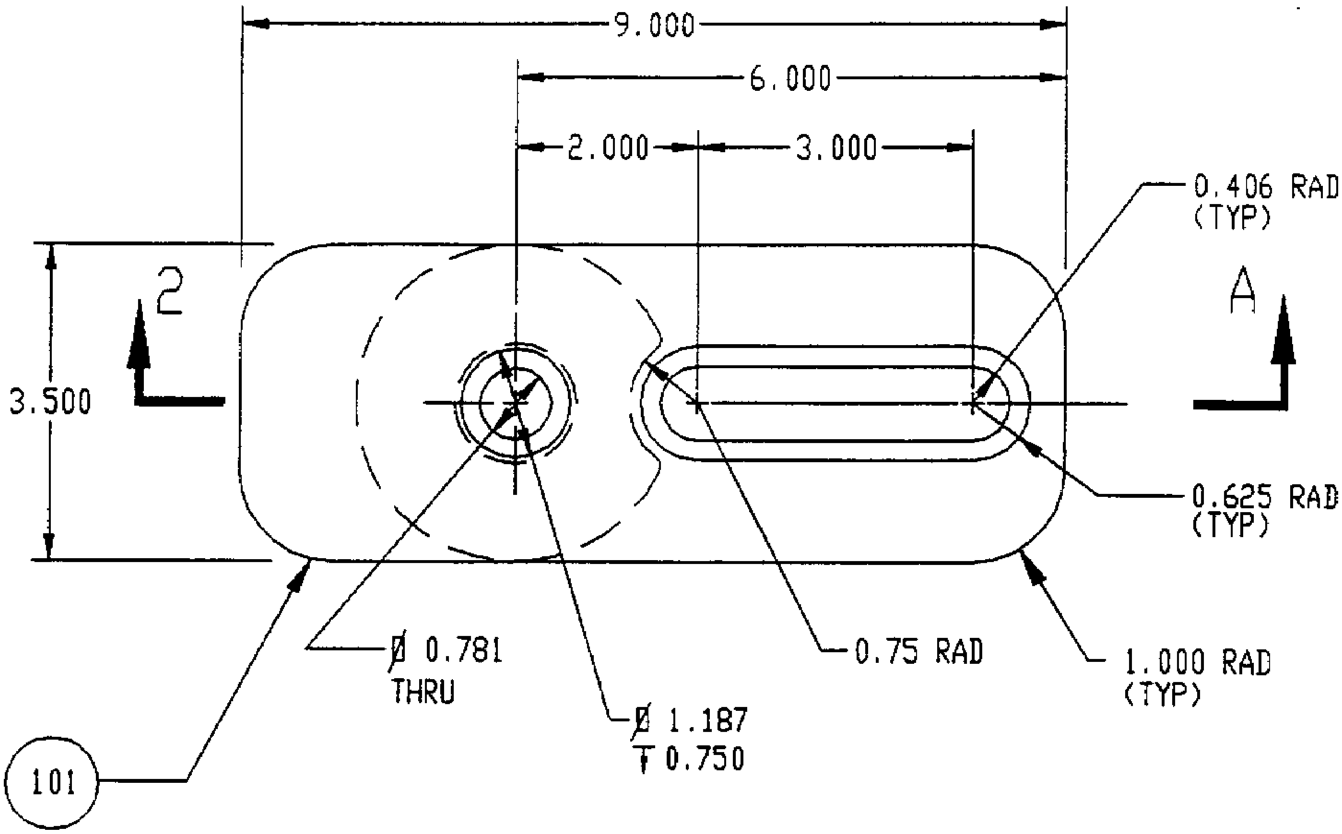
10. GRIND SMOOTH ALL SHARP CORNERS AND ROUGH EDGES LIABLE TO CAUSE INJURY TO PERSONNEL OR EQUIPMENT.

PRELIMINARY

GENERAL NOTES CONTINUED ON SHEET 6.

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–
SCALE: NONE			SHEET NO. 5	

PRELIMINARY



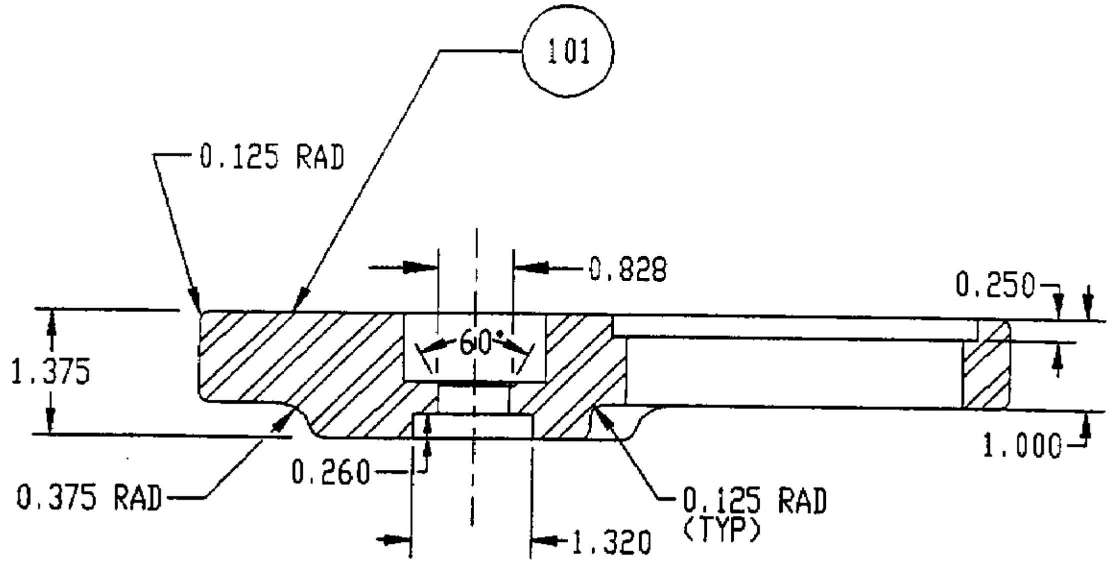
PLAN VIEW 1-A

SCALE: 6" = 1'-0"

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–
SCALE: SCALE			SHEET NO. 6	

PRELIMINARY



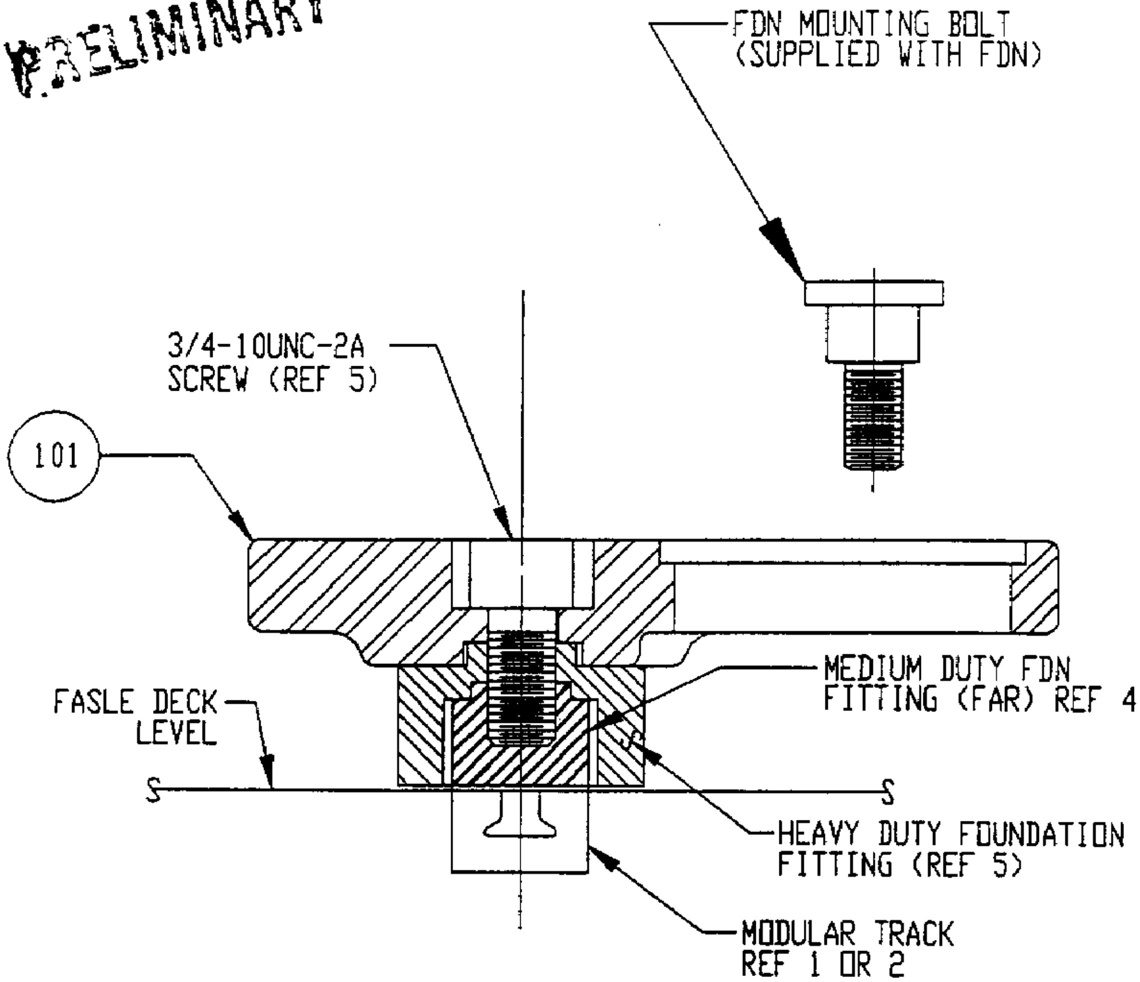
ELEVATION 2-A

SCALE: 6" = 1'-0"

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	—
SCALE: NONE			SHEET NO. 7	

PRELIMINARY



ELEVATION 3-A

TYP ARRANGEMENT OF MODULAR

TRACK, FITTINGS, AND ADAPTER

SCALE: 6" = 1'-0"

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–
SCALE: NONE			SHEET NO. 8	

LIST OF MATERIAL

PC NO	DESCRIPTION	QTY	MATERIAL	MATERIAL SPECIFICATIONS	STOCK NUMBER	UNIT WT LBS	REMARKS
101	61.2# PLATE	1 SF	HY-80	MIL-S-16216	9Z-9515-00-764-2407	61.2	

PRELIMINARY

PRELIMINARY

SIZE	FSCM NO.	WT GRP	NAVSEA DRAWING NO.	REV
A	53711	113	7037309	–
SCALE: NONE			SHEET NO.	